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FEBRUARY 1946

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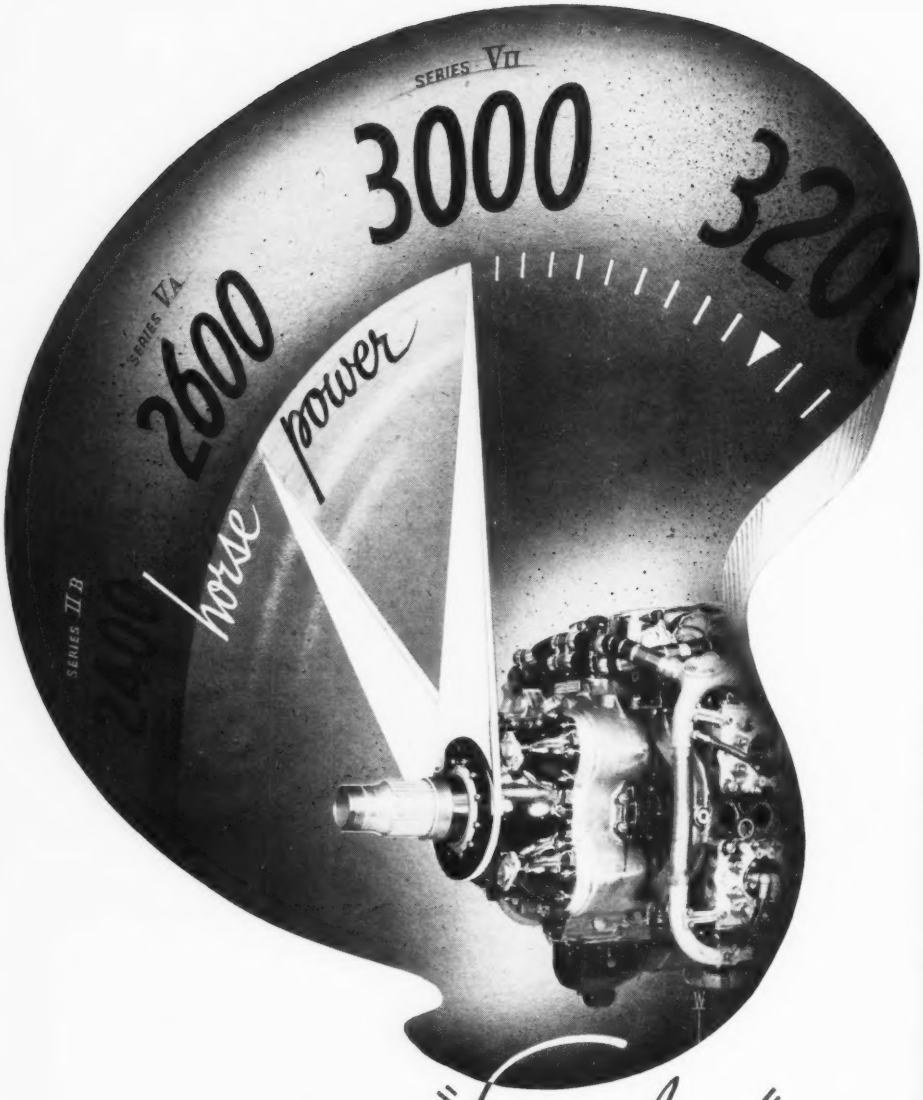

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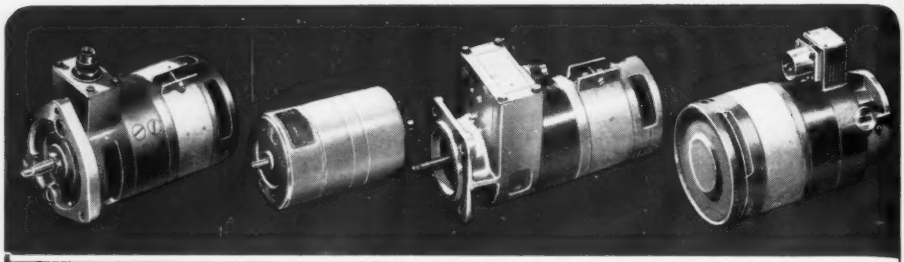

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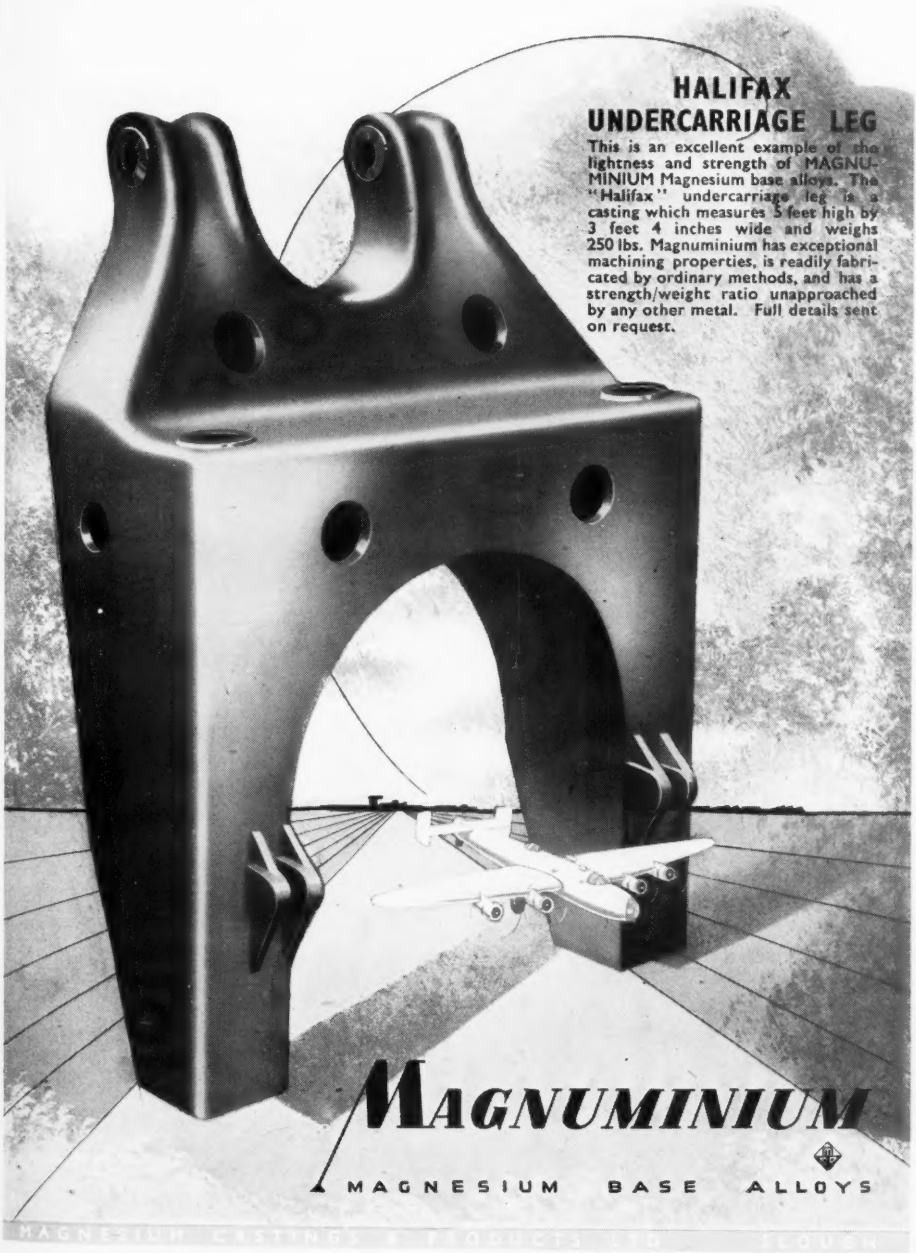
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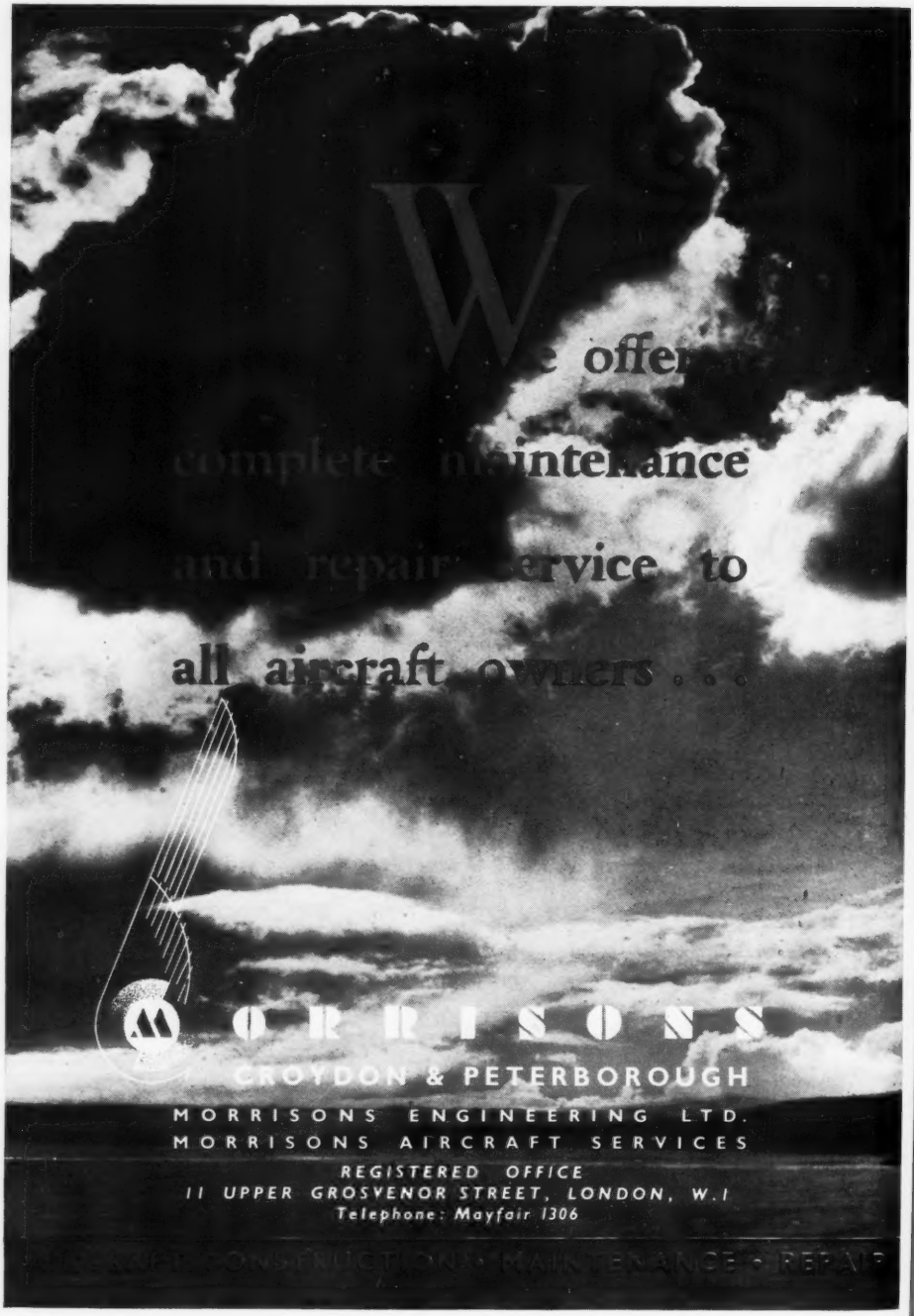
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THE JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY

With which is incorporated The Institution of Aeronautical Engineers

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The Journal of The Royal Aeronautical Society was founded in 1897 in succession to the Annual Reports. For the opinions expressed in Papers that are signed or initialled the authors alone are responsible. None of the papers or paragraphs must be taken as expressing the opinion of the Council of The Royal Aeronautical Society unless such is definitely stated to be the case. **The Journal is published monthly at the Offices of the Society, 4, Hamilton Place, Piccadilly, London, W.1.** Subscriptions per annum, £4 13 0 including postage; Single Numbers 7/6 or 7 9 post free. All communications for publication in the Journal, or on general matters affecting the Society should be addressed to — The Secretary, J. Laurence Pritchard, 4, Hamilton Place, W.1. The Society's Bankers are Messrs. Coutts and Co. All communications respecting Advertisement matters should be addressed to—The Advertisement Manager, Journal of The Royal Aeronautical Society, 4, Hamilton Place, W.1.

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A general view of the Eighteth Anniversary Dinner at Guildhall on the 11th January, 1946.
Taken from the Musicians' Gallery.

H.M. THE KING
Patron of The Royal Aeronautical Society.

H M. The King, Patron of the Royal Aeronautical Society.

In response to a loyal message of greetings from the President, on behalf of the Society, to its Patron, H.M. the King, the following reply was received :—

"The King sincerely thanks you and the members of the Royal Aeronautical Society for the message which you have sent to His Majesty in celebration of the Society's 80th Anniversary. As your Patron, the King sends his best wishes to you and to all members for your work, in which you have so long taken the lead and which to-day is of greater importance than ever before."

MESSAGES OF CONGRATULATION

received by the Society on its Eightieth Anniversary

The Prime Minister, the Rt. Hon. C. R. Attlee, C.H., M.P.

"My hearty congratulations to Royal Aeronautical Society on attaining its 80th birthday. As it was the first in the field, so may it always remain the premier scientific aeronautical body in the world."

The Rt. Hon. Winston S. Churchill, O.M., C.H., M.P., Hon.F.R.Ae.S.

"As the first Cabinet Minister to pilot an aeroplane 32 years ago, and as one of the youngest Honorary Fellows of the oldest aeronautical society in the world, I take a two-fold pleasure in congratulating the Society on its 80th birthday.

"I may remind its members, on this outstanding occasion in its long and great history, of a speech I made at the Guildhall in November, 1913, when I was First Lord of the Admiralty. I said then: 'I would venture to submit to this great company that the enduring safety of this country will not be maintained by force of arms unless in the whole field of aerial development we are able to make ourselves the first nation.'

"The first paper read before the Society, in 1866, laid down the engineering principles of the aeroplane, and the steadfastness of the Society's members through all the intervening years has brought its high reward in the field of aerial development.

"In every sphere of aeronautics—design, technical achievement, research—the leaders have been members of the Society. On its rolls indeed are inscribed the names of all those designers and research workers who have been responsible for the creation of the most outstanding military and civil aircraft of this country.

"I am glad to be able to pay my tribute to those who have done so much for the country and for the Society to which they belong."

Mr. Orville Wright, Hon.F.R.Ae.S.

"The Royal Aeronautical Society is the only Society founded previous to our flights in 1903 that from its beginning devoted its thought mostly to heavier-than-air machines. My heartiest congratulations to the Society on the pre-vision of its founders 80 years ago and on the ability of its present members to carry on so far beyond the prophetic vision of those founders."

Mr. Chas. H. Colville, F.R.Ae.S., President, Institute of Aeronautical Sciences, U.S.A.

"The Institute of Aeronautical Sciences sends greetings and salutations to the oldest and most distinguished aeronautical society in the world on its 80th birthday. May the great contributions to the aeronautical sciences your Society has made during the past four score years continue to encourage aeronautical scientists to even greater accomplishments. The Institute, which was founded by members of your Society, hopes that the cordial relationship of our societies may become even greater. Happy birthday to you!"

Dr. Edward P. Warner, Hon.F.R.Ae.S., President of the Interim Council, Provisional International Civil Aviation Organisation.

"I shall be thinking of you on the eleventh, as you gather in that historic scene, with affection and with pride in my own connection with a Society of such illustrious record."

Hon. Daniel McVey, Minister of Civil Aviation, Commonwealth of Australia.

"Many thanks to you and your Council for the kind invitation which I have just received by Beam wireless to join the Royal Aeronautical Society at dinner at Guildhall on January 11th, on the occasion of the Society's eightieth birthday celebrations.

"How I should love to be in London on that night so that I might join you. Even the time that would be involved in a return trip from Melbourne to London, however—short as it is—is more than can be spared at the moment. When that period of time is halved, as it will be within a year or two, how easy it will be when occasions such as these arise for us in the Dominions to join our colleagues in the heart of the Empire for a short week-end and be back at our desks without interruption to our normal work. Then will the Commonwealth and Empire be truly knit together, and only then, I believe, shall we feel that shortening, tightening and strengthening of the bond of Empire for which we are all striving and which is so essential to the full and proper development of our common heritage. The Royal Aeronautical Society has played a great part in the development of our air communications, and I should like to add my humble tribute to the work of the Society."

Hon. C. D. Howe, M.P., Minister of Reconstruction and Supply, Canada.

"Your invitation from Royal Aeronautical Society for dinner at Guildhall is greatly appreciated. Sincerely regret that I cannot attend for reasons you will understand. Eightieth birthday of this Society comes at a time when its contribution to current problems is more than ever necessary."

Lester D. Gardner, B.Sc., Hon.F.R.Ae.S., Chairman of Council, Institute of Aeronautical Sciences.

"Regret inability to attend Royal Aeronautical Society's Eightieth Birthday Dinner. May the cordial relationship of our Societies continue in the future as it has been in the fourteen years of the Institute's history. Personal greetings to my friends."

Professor J. C. Hunsaker, Hon.F.R.Ae.S., Massachusetts Institute of Technology.

"At Eightieth Birthday Dinner please express my cordial greeting and appreciation of the Society's leadership in the advancement of aeronautical science throughout the world. I am proud to be included in its Fellowship."

T. P. Wright, Hon.F.R.Ae.S., Administrator of Civil Aeronautics, U.S.A.

"Regret exceedingly other engagements prevent attendance at Guildhall dinner on January 11th. Please accept my hearty congratulations for the eighty years outstanding contributions to aviation of the Royal Aeronautical Society."

Air Vice-Marshal E. W. Stedman, C.B., O.B.E., A.R.C.Sc., Wh.Sc., F.R.Ae.S., Royal Canadian Air Force.

"Will you please convey to the Council my appreciation of their invitation to attend the dinner at Guildhall on the occasion of the Eightieth Anniversary of the Society.

"I very much regret that I shall be unable to be present on that occasion, but wish to extend to the Society my heartiest congratulations upon a magnificent record of achievement.

"During the life of the Society, aeronautics has developed from the realm of vision of a few brave and enthusiastic workers, to the great revolution in methods of transportation that is now taking place. Thus justifying the most optimistic dreams of the pioneers.

"The scientific standard of the Society has been maintained at a level which is a reflection of the high scientific attainments of its members of all grades.

"It is my hope that the Society will continue to advance in prosperity and achievement in the future as it has done in the past."

Among the many other messages of congratulation received by the Society were cables from the following:—

Air Vice-Marshal D. C. T. Bennett.

W. A. Burden, Esq.

Lt.-Col. G. A. Mann, M.B.E., Assoc. Fellow, Secretary, South African Branch.

Juan T. Trippe, President of Pan American Airways Inc.

Sir Frederick Tymms, K.B., A.C.G.I., M.C., Director-General, Civil Aviation, India.

New Zealand Branch of the Society.

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THE EIGHTIETH ANNIVERSARY OF THE SOCIETY

MORE THAN 350 members of the Society and its distinguished guests assembled in the historic and war-scarred Guildhall of the City of London on the night of Friday, the 11th January, 1946, to celebrate the Eightieth Anniversary of the Royal Aeronautical Society.

The guests included Mr. John Wilmot, M.P., Minister of Supply and Aircraft Production, Lord Winster, Minister of Civil Aviation; Marshals of the R.A.F. Sir Arthur Tedder and Viscount Trenchard, Air Chief Marshal Lord Dowding and many high-ranking officers of the Royal Air Force; Rear Admiral M. S. Slattery, Rear Admiral Sir Murray Sueter, Rear Admiral Troubridge; Lord Knollys, Chairman of British Overseas Airways Corporation, Sir William P. Hildred, Director-General of Civil Aviation; Attachés of the Armed Forces of the United States of America and of Soviet Russia; the City Sheriffs; and those concerned with the design, development, construction and operation of aircraft in Great Britain.

The guests were received by the President of the Society, Sir Frederick Handley Page, C.B.E., F.R.Ae.S., and by the Vice-Presidents, Sir Oliver Simmonds, F.R.Ae.S., and Dr. H. Roxbee Cox, F.R.Ae.S.

The Royal Artillery Orchestra, conducted by Captain O. W. Geary, M.B.E. (Director of Music R.A.) provided light music during the reception and dinner, by kind permission of the Officers of the Royal Artillery.

Grace was sung by the choir of the Savoy Chapel, by kind permission of the Vicar.

During dinner messages of congratulation (published elsewhere in this Journal) were read which had been received from H.M. The King (Patron of the Society), The Right Hon. C. R. Attlee, C.H., M.P., Prime Minister, The Right Hon. Winston S. Churchill, O.M., C.H., M.P., Hon. F.R.Ae.S., Mr. Orville Wright, Hon. F.R.Ae.S., and Mr. Charles H. Colville, F.R.Ae.S., President of the Institute of Aeronautical Sciences, U.S.A.

Sir Frederick Handley Page read the message from the King; those from Mr. Attlee and Mr. Churchill were read (amid great applause) by Sir Oliver Simmonds, and Dr. Roxbee Cox read those from Mr. Orville Wright and Mr. C. H. Colville. Dr. Roxbee Cox said that he had had the great pleasure, just three weeks previously, of meeting Mr. Orville Wright at Dayton, Ohio. Members would be glad to know that he was enjoying the best of health and spirits.

After the toast to the King had been honoured the President and Council drank a loving cup with their guests.

THE TOASTS

Lord Winster, who was to have proposed the toast to the Society, was unavoidably detained. His place was admirably taken by Mr. Wilmot, who had expected to reply to the toast of "The Guests."

MR. JOHN WILMOT, M.P. (Minister of Supply and Aircraft Production), proposing "The Royal Aeronautical Society," said he had been impressed by two outstanding characteristics of men of the air—their abiding faith and their abounding enthusiasm. They were quite infectious; indeed, he was himself infected.

That faith and that enthusiasm were apparently of no new growth. The quality of British air enthusiasts was such that, hardly had they become accustomed to the railway as a means of transport, they had become impatient of earth-bound travel altogether and had begun to ponder on the problems of flight. Thus, only 35 years after Stephenson's "Rocket" had made its first journey on the railway from Liverpool to Manchester, a group of enthusiasts had met in London—on the 12th January, 1866—and had solemnly formed a Society to do something which none of them had a very clear idea how to do and little chance of living long enough to see it done. That was an act of faith.

The Aeronautical Society of Great Britain was the first of its kind in the world. Fifty-three years after its formation it was graced with the "Royal" preface. It was indeed an honour to be its guest and to propose the toast.

But the Society had more than faith; it had at the same time an immense desire for knowledge. From the start it had known that only by the most devoted study of physical phenomena and by the most skilful engineering could the air be conquered. The aeroplane had been nurtured in science from its infancy. When one noted in the Society's records that in 1886 Captain Griffiths had lectured on "Jet Propulsion for Aeronautical Purposes" one realized that aeronautical science then, as now, walked with audacity.

Little more than forty years had elapsed since the Wright Brothers had flown; yet to-day, flying the Atlantic was common-place. Last Summer American Transport Command had flown 5,000 or 6,000 men per month across the Atlantic; and since last October the R.A.F. Transport Command had carried 125,000 men per month on scheduled services alone. That was astonishing progress by any showing.

Commenting on the evolution of the typical aeroplane during the past 30 years, from the wooden skeleton covered with fabric to the monoplane built of hollow shells of metal, Mr. Wilmot said that increasing speeds had rendered the drag of the external struts and bracings—which struts and bracings he had adjusted during the war of 1914-18 as a rigger in the Royal Naval Air Service—unacceptable, and indeed prohibitive.

Heavier wing loadings had turned the attention of designers towards the light alloys. The constant urge to restrict drag had led to retractable undercarriages, the reduction of the body size and the elimination of the carriage of all equipment in the air stream. The saving of space had become as serious a preoccupation as the saving of weight. The wing had been pressed into service for stowing wheels, for housing fuel and for the carriage of any part of the load that could be carried there. Thus we had arrived at the modern streamlined aircraft.

That revolution in design had already been accomplished before the outbreak of the War in 1939, and the time was then ripe for significant advances based upon established sound practice. Very great progress was made during the war, for a very good reason, that scientific and experimental advances were continually brought to the touchstone of practical test. Every sortie against the enemy was such a case.

In peace-time the practical test was in the field of Civil Aviation, in which field his colleague, Lord Winster, rendered such distinguished service. It was there that we must look primarily for the verdict as to the safety, reliability, economy, speed and

comfort of our aircraft. Those were the criteria of civil aircraft. Although he had mentioned comfort last, it was not the least important of those criteria. We must give much thought to the comfort of passengers. But whatever was done in that direction, no aircraft would be really comfortable unless its design as a whole were right .

The aircraft must be reasonably stable and must have effective control. Great improvements had been made in flying comfort as the result of the introduction of the automatic controls, which gave better results in straight flight than did the best of pilots; and those devices were capable of still further improvement. The problem of extending that form of control so that it would take the aircraft off the ground and bring it safely down to the ground, even in bad weather, was being actively pursued and no doubt would soon be solved.

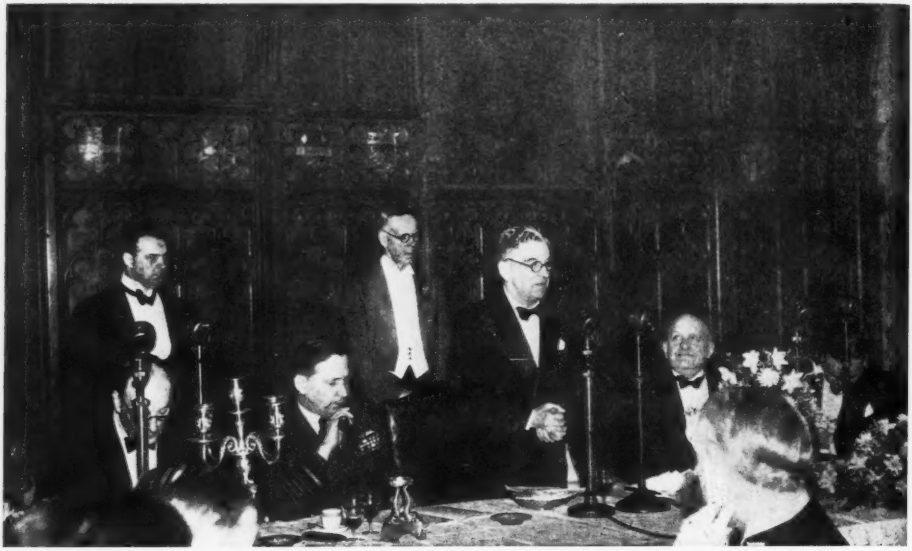
Long-range flight on the main trunk routes demanded the highest practicable speed. The aim was to connect the principal Capitals by an over-night flight. Cruising speeds of 350 m.p.h. were now in sight. To achieve those higher speeds we wanted less air drag and more engine power, or better still, both together. Much research effort had been and was being spent on low-drag wings, the underlying principles of which were now well understood, though he had gathered from Sir Frederick Handley Page that the manufacture and maintenance of such wings was not so easy.

Nevertheless, the Aircraft Industry had gone a very long way towards solving those problems, and it might be possible to make wings having less than half the drag of those now commonly used. But the body drag presented a problem much more difficult, a fact which led one to suggest that the tail-less aircraft in the medium sizes and the all-wing aircraft in the large sizes might prove on technical grounds to be the most promising designs for the really low-drag aircraft of the future.

As we approached speeds comparable with the speed of sound, new problems presented themselves. Not so long ago the speed of sound was regarded as presenting an impassable barrier : to-day we still regarded that speed with great respect, but we were not appalled by it. As a layman he had never quite understood why we should have to come to terms with the speed of sound ; but then he had never understood why the nuclear physicists should have to be on speaking terms with the speed of light. However, a great effort must and would be made to acquire the necessary knowledge in that field, with the same faith and the same enthusiasm among our aeronautical scientists and engineers as had been displayed by the founders of the Royal Aeronautical Society and which had marked progress since they had set out on their first great adventure.

It was fortunate that at this moment in the evolution of high-speed aircraft we should develop entirely new power plants, of which the most significant was the internal combustion turbine with jet propulsion. Its future lay in higher compression ratios and higher blade temperatures. The intensive study now proceeding would result undoubtedly in compressors giving double the present ratios, while metallurgical improvements should enable blade temperatures to be raised well above the present working level during the next few years.

Present-day types of aircraft derived their lift from stationary wings. But man's first thoughts in regard to flight had turned to flapping wings, in imitation of the bird, and rotating wings. In the fourteenth century Leonardo da Vinci had devoted several years of his remarkable life to the study of birds and mechanical flight, and his notebook contained sketches of aircraft with flapping wings. Perhaps even more interesting were



Lord Winster, Minister of Civil Aviation, speaking at the Eightieth Anniversary Dinner at Guildhall, 11th January. On the left are Marshal of the R.A.F. Lord Tedder, G.C.B., and Lord Brabazon of Tara, M.C., and on the right the President, Sir Frederick Handley Page, C.B.E., and Mr. J. Wilmot, M.P.

aircraft with lifting screws, running about a vertical axis, as in the aircraft known to-day as the helicopter.

Aircraft of that type, which would rise vertically from the ground, hover, descend vertically or fly forward at will at a reasonable speed, possessed great attractions. One gathered that it also presented great difficulties. He was informed that any competent designer could design a screw lifting surface which would suffice for hovering, but that it was not so easy to design one which would at once lift a useful load, remain stable and be controllable in forward flight.

Those problems were engaging some of the best brains in the Aircraft Industry, and they were confident of the outcome of their labours. The possibilities of an aircraft which could land and take-off in a space slightly larger than its own dimensions were very rich indeed. The helicopter might well become the air-taxi of the future, transporting passengers from the main airports to the towns.

Means of transport had always been a characteristic product of every civilization and a significant factor in its evolution ; so it was with us. We must either achieve an underlying unity of peoples or we must perish. Flying was potentially the greatest single factor in achieving that unity.

Hitherto air travel had been restricted to the few ; but there was no fundamental reason why that restriction should continue, and no reason to suppose that it would continue. We justly desired much greater opportunities of knowing the peoples of other lands, sharing their culture, understanding their problems, knowing what they wanted to do and why they wanted to do it. Indeed, unless we could reach forward to a wider social life we should fetter ourselves in our desire to create a world in which mankind could survive and could live

Lord Brabazon of Tara, M.C., and Marshal of the R.A.F. Lord Tedder, G.C.B., conversing during dinner. On the left is The Viscount Knollys, Chairman of the British Overseas Airways Corporation.

under conditions of peace and security, for which, deep down in their hearts, all people were eager.

In offering the toast, with which he coupled the name of the President, Sir Frederick Handley Page, Mr. Wilmot said the Royal Aeronautical Society had made a significant contribution. Wishing it well in its good work in the future, he concluded " The wind is in the shoulder of your sail."

THE REPLY

THE PRESIDENT responded. After thanking Mr. Wilmot for his very kind words concerning the Society, Sir Frederick Handley Page said the occasion was particularly memorable for the Minister. He had served as a rigger in the Royal Naval Air Service during the War of 1914-18, and had since become a Minister of the Crown. But he had risen to even greater heights, for on the anniversary of the Royal Aeronautical Society he had consented to become a member (applause). Thus, at last he had placed his feet on a firm foundation ! Having experienced the mundane attractions of a political life, he had realized that there was something more solid in a society which celebrated its 80th anniversary, perhaps as compared with a political party which, after all, had had a seeming existence for only the past 30 or 40 years.

Two outstanding dates in the history of our country were 1066, the date of the Norman conquest, and 1866, the date of the foundation of the Royal Aeronautical Society! In a country whose roots extended so far back into history, a history of development and expansion to Dominions and other self-governing States across the seas, there was no place in which the Society could more properly celebrate its 80th anniversary than in

Guildhall, in the centre of the City of London. The members were deeply indebted to the Lord Mayor, the Sheriffs and the City Corporation for having allowed them to hold their anniversary banquet in that great hall ; and they were honoured and privileged to welcome the Sheriffs.

There was another reason why they were privileged to attend the banquet in that hall, battle-scarred by reason of the attentions of their professional, though alien, brethren. Everyone who had their art and industry at heart would have wished that it should never have been applied in that particular direction.

Recalling events about the time he had joined the Society, nearly 40 years ago, the President said that in 1907 he had written to the Society to enquire how he could join and become interested in aeronautics. Like the Apostle Paul, however, he had received no reply to his epistle. Then he had decided to visit the office of the Society at 53, Victoria Street, London. The literature had stated that it possessed a library containing all the latest books, periodicals, and so forth in relation to aeronautics ; but he had only been able to find out on that occasion that it possessed a small office with a door which was locked !

Eventually, however, in December, 1907, he was elected to the Royal Aeronautical Society. Very shortly afterwards, being young and revolutionary, he had joined what was called a Reform Committee. That Committee was formed because the affairs of the Society were conducted by a number of gentlemen who had been elected as a Council, under the *aegis* of the Duke of Argyll, and who from that time onwards had been a self-elected body.

The members of the Reform Committee, being connected with the air and freedom, felt that anybody who had paid his subscription was entitled to representation. They had looked around at those old figures on the Council and had felt that the time had come when people with vision, and so on, should be on the Council and that the old people ought to be put down. Therefore they had attended the Society's general meeting and had claimed that there should be an elected body to take charge of the Society's activities. The meeting had broken up in confusion ; it was one of the most delightful meetings he had ever attended ! It would have given him hope for meetings in the Ministry of Aircraft Production or the Ministry of Civil Aviation if he had had sufficient foresight ! It was a meeting at which independence was asserted.

In 1911 the Society, after some 45 years of existence, was re-formed on its present technical basis, whereby Fellows and Associate Fellows were elected. Since then it had expanded on that same technical basis.

While referring to the history of the Society, Sir Frederick extended a special welcome to its oldest living member, Brigadier-General Sir Henry Osborne Mance, who had joined as long ago as 1899. He would have liked also to have welcomed another old friend, Mr. Griffith Brewer, who had joined the Society during the first two or three years of the present century. Unfortunately, because of a chill, he was unable to attend the banquet. Having been one of the first to fly with Wilbur Wright in France, he had obtained a " ticket " himself and had taken a very active part in flying. After many years he had discontinued flying ; but after a further period, at the age of 65 years, he had started flying again and had re-qualified.

Another to whom the President paid tribute was Captain J. L. Pritchard, who in the present year would celebrate the 25th anniversary of his appointment as Editor of

the Society's Journal and his 21st anniversary of his appointment as Secretary. To him and his staff a very great debt of gratitude was due for having made all the arrangements for the banquet, which arrangements had been most admirably carried out (applause).

But what of the future ? In aeronautics there was much to look forward to, something more than the mere development and improvement of physical phenomena. Our space of life was short, and we had to leave to others, not necessarily the finality, but the improvement of that which we were doing to-day.

One of the important matters to which the Society had addressed itself and was still addressing itself was the education of the next generation. The Society had technical committees dealing with various scientific and engineering developments—structures, aerodynamics, stressed skins, and so forth—and it had also a committee working in combination with the Society of British Aircraft Constructors in connection with the education of apprentices and the younger generation generally.

One of the things to which attention was being devoted more and more was to ensure that everybody who had the brains by which he could make a real addition to knowledge, had the chance to be trained and to give service in the aeronautical industry. Further, the older people such as himself must realize that the youth of the country could do just as well as themselves ; that they could do it for a few more hours each day and perhaps could do it a damned sight better. Youth was keen on work, and could do it sometimes with an inspiration which old timers might appear to lack.

To-day the people were suffering a great deal, not from the fatigue of the war, but rather from the fatigue of boredom, the fatigue of monotony, the fatigue of doing the same thing over and over again. We must give to youth who were really keen, the chance to see into the future, the chance to achieve those things which older people had for long tried to achieve and were still striving to achieve.

It had been inspiring to hear the Minister of Supply and Aircraft Production refer to faith, for faith, as Aristotle had said, was the road to learning. If one had not faith and a real desire to see a little further, one would never take the trouble to learn more. To learn faith, one should read Chapter 11 of " Hebrews," which began :—

> " Now faith is the substance of things hoped for, the evidence of things not seen."

If we had faith in the future, as the founders of the Society had had faith at a time when there were no prime movers light enough for their purpose in existence; if we had the faith to hand on our knowledge to the young people, to give them the chance and by doing so to give them inspiration, the Society, which had done so much in the past, would do equally well in the future.

THE GUESTS

LORD BRABAZON OF TARA, M.C., F.R.Ae.S. (Past-President) proposed the toast, " The Guests."

In the first place, however, it being fitting to talk of the past on the occasion of an anniversary, he recalled the time when people who tried to think of flying were classed as those who were hunting for the Philosopher's Stone or looking for perpetual motion. They were classed as amiable lunatics ; even to-day they were sometimes called amiable. He had made no great contribution publicly to aeronautical science, but the fact that he had taken the first " pig " [the name sometimes applied to early biplanes.—Ed.] into

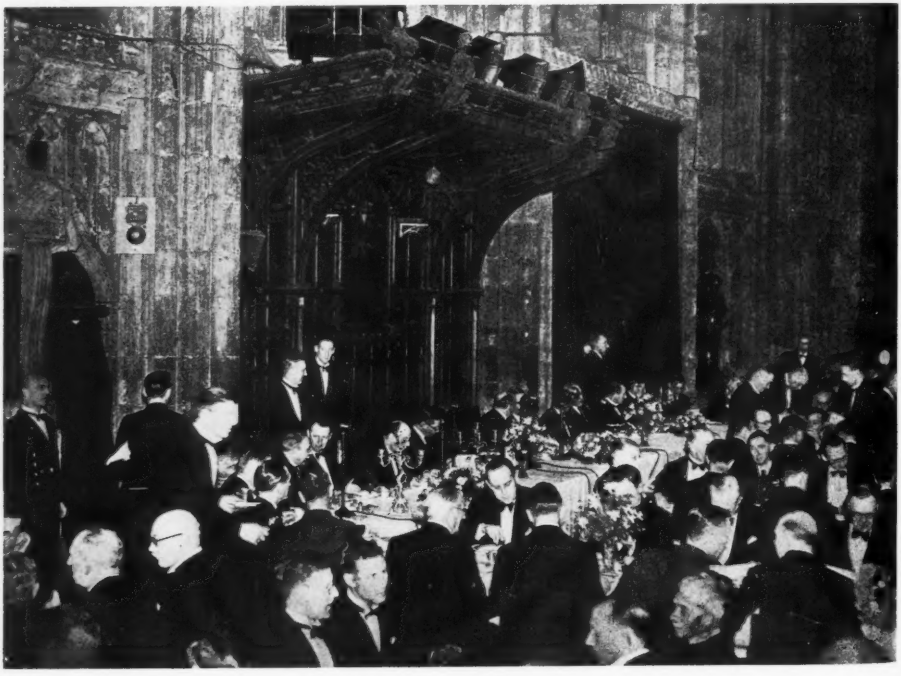
the air in this country had certainly marked a point in our aeronautical history. He was once referred to as the first " certified " pilot !

It was interesting to note how respectable the aeronautical people had become. They were gathered together in the great Guildhall of the City of London, at the very centre of the Empire, most of them wearing evening clothes ; others were debarred from wearing evening clothes chiefly because all the suiting in the world was being made into parachutes. Aeronautics had certainly upset our private lives !

He asked the guests, jocularly, to pay to members of the Society the respect which they deserved. Captain Pritchard and the Council had seen to it that in order to become a Fellow of the Royal Aeronautical Society, one must pass an examination, indicating that at some time one must have known something about aeronautics.

The present was an age of science, and we were all scientists. The development of experimental apparatus was such that the power required to produce a gentle draught in the latest wind tunnel was equal to the power of all the generating stations supplying Manchester . Naturally, the State had to step in to pay for such luxuries; and policy was directed by people who knew nothing about it . So we advanced !

Reminding the gathering of the birth of heavier-than-air flight in America, Lord Brabazon recalled that people with great resources had backed the scientists mainly against two brothers who had lived at Dayton, Ohio. Sometimes we forget how keen had been the race between the two factions. It was on the 8th December 1903 that Langley



A general view of the top table at the Eightieth Anniversary Dinner at Guildhall on the 11th January.

The President, Sir Frederick Handley Page, C.B.E., speaking at the Eightieth Anniversary Dinner. On the right are Mr. John Wilmot, M.P., Minister of Supply and Aircraft Production, and Viscount Trenchard, Hon. Fellow.

had met his second and final disaster on the Potomac River; and only nine days after that the Wright brothers—Orville in particular—had made their famous flight. It was not always appreciated how near were those two flights.

He called attention to those events, not by any means to belittle research, but rather to try to give back to the individual faith in his strong right arm, faith in his own initiative and his own imagination, for there was plenty yet to be learned. It would not all be learned in great organizations using expensive apparatus. There was much that had been done, and would be done in the future, by individuals. Einstein, by the exercise of his own imagination, had laid down a formula which had revolutionized fundamental physics.

In aeronautics also there had been many changes. Langley had started with a tandem monoplane ; the Wrights came in with a biplane ; the French had tried to speed things up by using a monoplane ; then Tom Sopwith had beaten hell out of them with a biplane ; later there were the great Douglas multi-engined machines, tractor machines, which represented the foundation of our great bombers ; and now along came Whittle with his new power plant and we were back to pushers again.

But we must still struggle on with all sorts of new things, at the same time taking heed of the lessons which back numbers had taught us and, as the Minister of Supply and Aircraft Production had said, we must try to give sound the go-by. No one must

be oppressed or depressed by the fact that so much had been done already. In spite of the advances made during the past 80 years, a lot remained still to be done. We were still at the beginning. It was of no use tamely copying other people and trailing along behind them, for that would lead nowhere. It was necessary to skip a step or two with imaginative conception.

Lord Winster had said in the House of Lords a few days ago that the Brabazon Committee had recommended two and a half years ago the building of jet machines. Where were they to-day ? One hoped that we could impress upon our Ministers that no one in the Royal Aeronautical Society or in the world would blame the State at all for trying to beat the world, even if they failed sometimes. They would fail if they did not show an adventurous pioneer spirit, but were content to drift into a stale state of safety-first, which would get us nowhere.

The Royal Aeronautical Society was a scientific body and its members, like most technicians, had introduced to the world inventions which political man had been ill-equipped mentally to use. It was a sad story. We could call to mind the dreams of those who had given their lives in the development of something which could bring about a better understanding throughout the world. No one could blame them for the fact that the bomber had been developed ; one might as well rank Lord Rutherford as a war criminal because his atomic philosophy had led to the atomic bomb.

However, after the Society had been in existence for 80 years we were making another start. There were many others in the political world who had tried, very unpopularly, to get military and civil aviation separated. That had come about, and the Society had the privilege of greeting one of our first Ministers of Civil Aviation, Lord Winster. (applause). But that development had only just happened ; and the situation to-day might well be described by a paraphrase of Shakespeare's words :

> " Now is the ' Winster ' of our discontent
> Made glorious summer by this sun of York. . . "

History repeated itself, and to-day we had come to the Tudor age ; but we were not any further.

Of all the murky jobs which he would hate to do, it would be that of the Minister of Civil Aviation. There were all the technical difficulties, the new technique, the international equations, the administrative difficulties, the general lack of experience, and around it all played the fire of a test of ideologies. It must be a very tiresome job, and it was for all who were concerned with, and who were interested in, aviation to pledge him from the bottom of their hearts all the assistance of which they were capable on the technical side.

One thing which would help the Minister of Civil Aviation a great deal would be the complete disappearance of the Ministry of Aircraft Production ! (laughter). Mr. Wilmot, who appeared to be very prosperous and to enjoy extremely good health, was dual Minister of Supply and of Aircraft Production. He led a sort of " Jekyll and Hyde " life, popping between the Strand and Millbank, invariably being in the place other than that at which one tried to find him. But what a task was his ! No one who had not been in a Department could visualize for a moment the astonishing difficulties of a Minister trying to suppress the Department of which he was the Head. That was more difficult than a war. Anything in the way of an endeavour to suppress a Department was always the thing that the Department resisted most.

In spite of the hope that the Ministry of Aircraft Production would disappear, however, they all hoped most sincerely that Mr. Wilmot would not disappear. (hear hear). They liked him and they hoped he would rise to even greater heights in political life, even if he displaced some of his colleagues !

Inviting the members of the Society to drink the health of their many very distinguished guests, Lord Brabazon coupled with it the name of Lord Winster, the Minister of Civil Aviation.

THE REPLY

LORD WINSTER, in his response to the toast, apologized for his absence earlier in the evening. He expressed his sense of honour and privilege in being present among so brilliant an assemblage. He was glad also to have been able to listen to the President's witty and racy speech, which had left him, as Minister of Civil Aviation, hoping that the President's knowledge of aerodynamics was equal to his knowledge of the Bible ! (laughter).

Commenting on Mr. Wilmot's reference to cruising speeds of 350 m.p.h., Lord Winster said he felt that that figure was rather modest. In the course of discussion with a foreign Ambassador shortly after taking office he had remarked on the terrifying thought that even with the aid of modern aeroplanes it was impossible to get more than 56 hours away from our creditors or wives. He had made that remark in his ignorance, for he had since had to become accustomed to ideas of speeds far exceeding 350 m.p.h.; he had been introduced into the world of supersonic speed.

While he had to admit that such speeds would enable our wives and creditors to catch up with us rather more rapidly than he had anticipated, they would at least enable us not to hear the remarks that were made ! but whatever speeds might be attained, he intended to do all the flying he possibly could do, because with him it was a case of now or never ! Either he would fly in this world or he would never fly at all !

Recalling another remark by Mr. Wilmot, concerning comfort, Lord Winster said that in respect of civil aviation he would place the requirements in the order—regularity of service, safety, and then proper comfort and convenience for the passengers. He urged that we should get away from all the *de luxe* ideas about air travel. Let us set our faces against them and cease to associate air travel with such ideas.

With regard to jets and gas turbines, and the accompanying problem of pressurisation —which latter was not a problem by itself, but was one of a whole series of related problems—it was in that field that we were presented in this country with great opportunities for the future of civil aviation ; it was there that we should come into our own. His only fear, when he heard of the many ideas which the air experts were putting forward, was that there were more ideas abroad to-day than there were technicians and scientists to research into them. The shortage of technicians and scientists represented one of our most grave problems.

Nevertheless, having visited several of our great aircraft firms, and having enjoyed discussions with the heads of those firms, and with the designers and technicians, he had been immensely encouraged. He was able to appreciate that not only had we the enthusiasm which was necessary at this moment to give us our rightful place in the air of the future, but we had also, in full measure, the ability which would give us that place. His visits to those various works had dissipated his fear for the future.

As to the admirable speech made by his noble friend, Lord Brabazon, Lord Winster assured him that we in this country were not going to copy others, but that we were going to set the pace, which would be a pace indeed. We would follow up and bring to fruition the new ideas of which he had spoken, and in the long run it would be found that other countries were following us rather than that we should be following others. As Minister of Civil Aviation he was prepared to have a dare on the new ideas ; and safety-first did not appeal to him.

Characteristically, Lord Brabazon had quoted Shakespeare wrongly, and his quotation might have given the impression that he was pinning his faith on the " York." While paying his respects to the York, Lord Winster said that the quotation should be :

" Now is the winter of our discontent
Made glorious summer by this ' son ' of York. . . ";

It was through the sons and grandsons of the " York " that this country would come into its own. (applause).

In thanking Lord Brabazon for his pledge of support to the Ministry of Civil Aviation, he said he accepted the words as being meant in the spirit as in the letter. He was grateful to all present because, by the spirit they had shown in response to the speeches, it was evident that they intended to give the Civil Aviation of this country their warm and hearty support. But in spite of the charm of Lord Brabazon's words, he was not going to drive a wedge between the two Ministers. (laughter). In the spirit of co-operation and mutual good-will which, he was happy to say, existed between John Wilmot and himself there was indeed a happy augury and a good omen for the future success of civil aviation.

In conclusion, Lord Winster expressed his thanks for the kindness and encouragement shown to the cause of civil aviation by the Society and its guests. Most heartily he wished the Society and all its members every success in the future.

LIST OF GUESTS

The following is a list of the members and guests who were present at Guildhall:—

Capt. P. D. Acland (*Companion*); S/Ldr. H. F. T. Adams (*Associate Fellow*); C. V. Allen, Esq.; Major R. H. Archbald, F.R.S.A., F.R.G.S. (*Fellow*); E. J. N. Archbold, Esq., B.Sc. (*Graduate*); F. W. Atkinson, Esq. (*Associate*); J. Austin, Esq. (*Associate*).

A. A. Bage, Esq. (*Associate Fellow*); Ai Marshal Sir John E. A. Baldwin, C.B., C.B.E., K.B.E., D.S.O., O.B.E., A.D.C., R.A.F. (*Associate Fellow*); Major C. J. P. Ball, D.S.O., M.C. (*Fellow*); R. M. Balston, Esq. (*Founder Member*); A/Cmdre F. R. Banks, C.B., O.B.E., M.I.A.E., M.S.A.E. (*Fellow*); Dr. A. Buchanan Barbour (*Associate Fellow*); F/Lt. J. S. P. Barrett (*Associate*); Miss F. Barwood; E. L. Bass, Esq. (*Fellow*); Sheriff F. Tidbury Beer; John Bell, Esq. (*Associate*); F/O W. R. Bendall (*Associate Fellow*); A. Gordon Berg, Esq., B.E. (*Associate Fellow*); Sir James Bird, R.N. (retd.), M.I.N.A. (*Fellow*); S/Ldr. H. C. Black (*Student*); R. Blackburn, Esq., O.B.E., A.M.Inst.C.E., M.I.M.E. (*Fellow*); E. W. Bonar, Esq., G.C. (*Associate Fellow*); S/Ldr. T. A. V. Booth (*Associate*); Air Marshal Sir N. Bottomley, K.C.B., C.I.E., D.S.O., H.Q. Bomber Cmd. R. H. Bound, Esq. (*Fellow*); E. C. Bowyer, Esq., Director S.B.A.C.; The Rt. Hon. Lord Brabazon of Tara, M.C. (*Fellow*); Air Cmdre. H. G. Brackley, C.B.E., D.S.O., D.S.C. (*Associate Fellow*); Mrs. J. Bradbrooke; J. W. S. Brancker, Esq. (*Associate*); F. S. A. Brett, Esq. (*Associate*); Leonard Bridgman, Esq.; Lt.-Col. W. A. Bristow, M.I.E.E., M.I.A.E. (*Fellow*); Sir Harry Brittain; H. W. J. Brittlebank, Esq., B.Sc. (*Associate Fellow*); H. E. Broadsmith, Esq., M.E., M.I.A.E. (*Fellow*); C. N. Brown,

Esq. (*Associate*); D. L. Brown, Esq., A.M.Inst.C.E. (*Associate Fellow*); Sir William Brown, Permanent Under Secretary to Air Ministry; Prof. Burgess, Aerodynamics Prof. at Delft University; Lt. Cmdr. J. R. Bryans (*Associate*); G/Capt. G. M. Bryer, O.B.E., A.F.C. (*Associate Fellow*); Sir John S. Buchanan, C.B.E., A.M.I.Mech.E. (*Fellow*); F. E. Buckell, Esq. (*Associate Fellow*); Major G. P. Bulman, C.B.E., B.Sc., Member of Council (*Fellow*); G/Capt. P. W. S. Bulman, M.C., A.F.C., C.B.E. (*Fellow*); G. B. Burnside, Esq., M.I.Mech.E., F.R.S.E. (*Associate Fellow*).

S. Camm, Esq., C.B.E. (*Fellow*); J. D. Campbell, Esq., B.Sc., A.R.T.C. (*Associate Fellow*); R. L. Carstairs, Esq. (*Student*); F/Lt. F. R. Carter (*Associate*); Roy Chadwick, Esq., M.Sc., F.R.S.A. (*Fellow*); W. Challier, Esq. (*Associate Fellow*); H. E. Chaplin, Esq., M.B.E., A.M.I.Mech.E. (*Fellow*); R. H. Chaplin, Esq., O.B.E., B.Sc. (*Fellow*); Miss L. Chitty (*Fellow*); A. E. L. Chorlton, Esq., C.B.E., M.Inst.C.E., M.I.Mech.E. (*Fellow*); J. E. Chorlton, Esq. (*Associate Fellow*); R. A. Clare, Esq., B.Sc. (*Associate Fellow*); F/O A. J. Clark, B.Sc. (*Associate Fellow*); S. A. Clark, Esq. (*Associate*); A. J. Clifton, Esq. (*Student*); A. C. Clinton, Esq. (*Fellow*); E. W. Coates, Esq., G.I.Mech.E. (*Associate Fellow*); Sir Alan J. Cobham, C.B.E., A.F.C (*Hon. Fellow*); H. G. Conway, Esq., M.A., A.M.I.Mech.E. (*Associate Fellow*); C. Cooper, Esq., B.Sc.(Eng.) (*Associate Fellow*); Major J. L. B. H. Cordes (*Associate Fellow*); B. Cornthwaite, Esq. (*Associate*); F/Lt. L. W. Cotter (*Associate*); Air Chief Marshal Sir Christopher Courtney, K.C.B., D.S.O.; H. J. Crampton, Esq. (*Associate Fellow*); F. F. Crocombe, Esq., A.C.G.I., D.I.C., B.Sc. (*Fellow*); C. Stanley Crosse, Esq.; G/Capt. W. N. Cumming (*Associate Fellow*); Miss E. L. Curtis (*Associate*).

Sir Charles Darwin, K.B.E., M.C., Director N.P.L.; A. Davenport, Esq. (*Fellow*); Capt. E. Keith Davies (*Associate Fellow*); G/Capt. R. M. Davy (*Associate Fellow*); H. R. Day, Esq. (*Associate Fellow*); A. M. Desoutter, Esq. (*Associate Fellow*); Deputy Charles G. Dickson; L. W. Dixon, Esq. (*Associate*); Sir Roy Dobson, K.B., C.B.E. (*Fellow*); R. N. Dorey, Esq. (*Fellow*); W/Cmdr. A. J. Douch, M.A., F.R.Met.S. (*Associate*); Mrs. Ann C. Douglas (*Associate*); Air Chief Marshal Lord Dowding, G.C.B., C.M.G.; G. H. Dowty, Esq. (*Fellow*).

W/Cmdr. A. J. Edmunds (*Associate*); G. R. Edwards, Esq., B.Sc., A.M.I.Struct.E. (*Associate Fellow*); P. F. N. Edwards, Esq. (*Student*); C. Robson Elgie, Esq. (*Associate*); D. L. Ellis, Esq., B.Sc., A.R.T.C. (*Fellow*); E. C. Gordon England (*Fellow*); D. S. Erulkar, Esq. (*Companion*); Capt. Mrs. Rosamund Everard-Steenkamp (*Associate*).

W. S. Farren, Esq., C.B., M.B.E., M.A., F.R.S. (*Fellow*); Sir Roy Fedden, M.B.E., D.Sc., M.I.A.E. (*Fellow*); Lt.-Col. L. F. R. Fell, D.S.O., O.B.E., M.I.Mech.E. (*Fellow*); F. H. Fisher, Esq., Managing Editor, *British United Press, Ltd.*; G. E. Folkes, Esq., C.P.A., M.I.Mech.E. (*Associate Fellow*); F. A. Foord, Esq. (*Fellow*); C. A. Forecast, Esq. (*Associate*); Capt. A. Graham Forsyth, B.Sc., M.I.M.E., M.Inst.M.E. (*Fellow*); H. E. Fozard, Esq. (*Associate Fellow*); H. A. Francis, Esq., A.F.C., M.A. (*Fellow*); Sir Peirson Frank, President Inst. Civil Eng.; Major N. W. H. Freeman, A.Inst.Aut.E., (*Associate*); L. G. Frise, Esq., B.Sc. (*Fellow*); G. H. Fuller, Esq. (*Associate*).

W/Cmdr. G. L. Gandy (*Associate*); S/Ldr. C. Gardner, B.B.C. Air Correspondent; H. H. Gardner, Esq., B.Sc. (*Fellow*); Air Marshal Sir Guy Garrod, C.B., O.B.E., M.C., D.F.C. (*Associate*); U. K. Gerry, Esq. (*Student*); W. J. Gessey, Esq., (*Associate*); W/Cmdr. T. F. Gill, D.S.O., Dep. Air Officer Commanding R.N.Z.A.F.; T. Gillett, Esq. (*Associate*); H. Goodwin, Esq. (*Associate Fellow*); Lord Gorell, Chairman Royal Aero Club; P. Goudime-Levkovitsch, Esq., B.A. (*Associate Fellow*); A. Gouge, Esq., B.Sc., Past President (*Fellow*); G. T. Gray, Esq. (*Associate*); J. M. Gray, Esq., B.Sc. (*Associate Fellow*); H. S. Green, Esq., A.M.I.M.E. (*Fellow*); L. S. Greenland, Esq., (*Associate Fellow*); K. H. Greenly, Esq., B.Sc. (*Associate Fellow*); E. J. Gregson, Esq. (*Associate Fellow*); C. G. Grey, Esq. (*Founder Member*); P. T. Griffith, Esq. (*Associate Fellow*); S/Ldr. D. Hilton Grundy (*Associate Fellow*).

H. M. Hackett, Esq. (*Graduate*); L. J. Hakes, Esq. (*Student*); Major F. B. Halford, M.S.A.E. (*Fellow*); Sir Frederick Handley Page, C.B.E., President (*Fellow*); M. C. Harley, Esq. (*Associate*); R. B. Hawkes, Esq. (*Student*); C. V. Haworth, Esq. (*Associate*); C. A. Hedger, Esq. (*Associate Fellow*); J. N. D. Heenan, Esq. (*Associate Fellow*); Major H.

Hemming, A.F.C., F.R.G.S. (*Fellow*); A. J. Henderson, Esq. (*Associate*); J. Aherne Heron, Esq. (*Associate*); Sir William Hildred, D.G.C.A.; Prof. G. T. R. Hill, M.C., M.Sc., M.I.Mech.E. (*Fellow*); Capt. P. V. Hoare, A.M.Inst.C.E., D.I.C. (*Associate Fellow*); C. F. Hodson, Esq. (*Associate Fellow*); W/Cmdr. C. Hole (*Associate*); Air Marshal Sir Leslie Hollinghurst, K.C.B., C.B., D.F.C.; J. Vivian Holman, Esq., M.I.Ae.S. (*Associate Fellow*); F. J. B. Holmes, Esq. (*Associate*); Capt. J. G. Hopcraft, O.B.E., M.C. (*Associate Fellow*); D. F. Horne, Esq., M.B.E., A.M.I.Prod.E. (*Associate Fellow*); Air Cmdre. E. L. Howard Williams, M.C., D.Litt., M.A., D.I.C. (*Associate Fellow*); A. J. Hughes, Esq., O.B.E., F.R.G.S., M.R.I. (*Fellow*); S/Ldr. M. G. Hunn (*Associate Fellow*).

Captain John J. Ide, U.S.N.R., Temp. Hon. Member.

B. Jablonsky, Esq. (*Associate Fellow*); A. N. Jackson, Esq., B.Sc.(Eng.) (*Associate Fellow*); C. H. Jackson, Esq., B.Sc., A.C.G.I., D.I.C. (*Associate Fellow*); Thurstan James, Esq., Editor, *The Aeroplane*; S/Ldr. A. M. Jardine, A.F.C. (*Associate*); L. W. Johnson, Esq., M.C., M.Met., M.I.A.E. (*Associate Fellow*); Mrs. Patricia Johnson (*Companion*); E. T. Jones, Esq., M.Eng. (*Fellow*); C. F. Joy, Esq. (*Associate Fellow*); G. L. Keen, Esq. (*Associate Fellow*).

R. P. Key, Esq., B.Sc., A.M.Inst.C.E. (*Fellow*); R. S. Khot, Esq., M.A., M.Sc., D.I.C. (*Associate Fellow*); W/Cmdr. C. Kimber, D.F.C. (*Associate Fellow*); E. P. King, Esq., B.Sc. (*Fellow*); E. Gibson Knight, Esq. (*Associate Fellow*); Lord Knollys, Chairman British Overseas Airways Corporation; J. Korab-Rulikowski, Esq. (*Associate Fellow*).

J. E. Lamb, Esq. (*Associate Fellow*); Capt. A. G. Lamplugh (*Fellow*); W/Cmdr. S. W. Lane (*Associate Fellow*); A. D. Lang, Esq. (*Associate Fellow*); M. Langley, Esq. (*Fellow*); W. F. Leadbeater, Esq. (*Student*); R. E. Leete, Esq. (*Associate Fellow*); Dr. D. M. A. Leggett (*Associate Fellow*); F. S. Lester, Esq. (*Associate*); M. Lewin, Esq. (*Associate Fellow*); F. H. M. Lloyd, Esq. (*Associate Fellow*); J. W. Loader, Esq., B.Sc.(Eng.) (*Associate Fellow*); B. Lockspeiser, Esq., M.A., F.C.S. (*Fellow*); W/Cmdr. J. L. Longden (*Associate Fellow*); Air Chief Marshal Sir Arthur M. Longmore, C.B., G.C.B., D.S.O., R.A.F. (*Founder Member*); Capt. (E) M. Luby, R.N. (*Associate Fellow*); P. G. Lucas, Esq. (*Fellow*); Air Chief Marshal Sir Edgar Ludlow-Hewitt, G.C.B., K.C.B., C.M.G.

Sir Francis K. McClean, A.F.C. (*Fellow*); W/Cmdr. C. G. B. McClure, A.F.C., B.A. (*Associate*); A. I. McCutchan, Esq. (*Graduate*); Mrs. D. W. McLaren.

P. Macartney, Esq. (*Associate*); Dr. J. W. Maccoll, B.Sc., Ph.D. (*Fellow*); R. Makepiece, Esq.; Brig. Gen. Sir H. Osborne Mance, K.B.E., C.B., C.M.G., D.S.O. (*Companion*); J. F. Marsh, Esq. (*Associate*); Lt.-Col. W. Lockwood Marsh, O.B.E., M.A., LL.B., A.F.I.Ae.S. (*Fellow*); W. F. F. Martin-Hurst, Esq. (*Associate*); Major R. H. Mayo, O.B.E., M.A., A.M.Inst.C.E. (*Fellow*); Lt.-Cmdr. (A) F. W. Merriam, A.F.C. (*Fellow*); W. A. Millard, Esq. (*Associate*); Dr. Betty Morgan, B.B.C. European Service; W/Cmdr. J. R. Morgan, A.M.I.Mech.E., A.M.I.M.E. (*Associate Fellow*); M. B. Morgan, Esq., M.A. (*Fellow*); W. D. Murray, Esq., (*Associate Fellow*); W/Cmdr. M. Murzynski (*Associate Fellow*); Lt. (A) T. M. Myles, R.N.V.R. (*Associate*).

A. H. Narracott, Esq., *The Times;* A. R. B. Nash, Esq., B.Sc., A.M.Inst.C.E. (*Associate Fellow*); F/O C. H. Latimer Needham, M.Sc. (*Fellow*); W. F. Newell, Esq., B.Sc. (*Associate Fellow*); Capt. E. C. Nicola (*Associate Fellow*); Major R. E. Nicoll; R. L. Ninnes, Esq. (*Fellow*); F. Nixon, Esq., B.Sc., M.I.Aut.E. (*Fellow*); A. E. Woodward Nutt, Esq., B.A. (*Fellow*).

C. E. Oake, Esq., M.B.E. (*Associate*); E. Ower, Esq. (*Fellow*).

F. W. Page, Esq., B.A. (*Associate Fellow*); J. Lankester Parker, Esq., O.B.E. (*Fellow*); H. N. Patel, Esq., B.Sc., A.C.G.I. (*Graduate*); S. J. Patmore, Esq., A.M.I.MechE., A.M.I.E.E. (*Associate*); E. Paulsen, Esq. (*Associate*); Mrs. Dorothy Pearse (*Associate*); S/Ldr. R. C. I. Pearse (*Associate*); H. J. Penrose, Esq. (*Fellow*); W. E. W. Petter, Esq., B.A. (*Fellow*); G. E. Petty, Esq. (*Fellow*); C. W. Pidock, Esq. (*Associate Fellow*); R. K. Pierson, Esq., O.B.E., B.Sc., A.M.Inst.C.E. (*Fellow*); Miss E. Pike, B.A. (*Graduate*); F. Pilling, Esq. (*Associate Fellow*); A. R. Pitt Esq. (*Associate Fellow*); Capt. L. Plugge (*Fellow*); F. H. Pollicutt, Esq. (*Fellow*); S/Ldr. C. H. Potts (*Associate Fellow*); C. M.

Poulsen, Esq., Editor *Flight; Press Association;* S/Ldr. R. C. Preston, A.F.C. (*Associate Fellow*); Air Cmdre. W. H. Primrose (*Associate*); Capt. John Laurence Pritchard, Hon. F. Inst. Aero. Sc. (Secretary) (*Hon. Fellow*); C. G. Pullin, Esq. (*Associate Fellow*).

F. Radcliffe, Esq., B.Sc. (*Fellow*); J. D. Rademan, Esq., Civil Air Liaison Officer South Africa; G. Ratcliffe, Esq., G.I.Mech.E. (*Graduate*); J. W. Ratcliffe, Esq. (*Fellow*); Dr. J. Ratzersdorfer (*Fellow*); W. M. Reichsfeld, Esq., M.I.E.T. (*Associate Fellow*); Colin Reid, Esq., *Daily Telegraph;* Air Cmdre. G. Silyn Roberts, M.Sc., A.F.C. (*Associate Fellow*); F/Lt. C. L. Ross (*Companion*); F/Lt. R. J. Ross (*Student*); F. Rowarth, Esq. (*Fellow*); N. E. Rowe, Esq., C.B.E., B.Sc., D.I.C. (*Fellow*); Dr. H. Roxbee Cox, D.I.C., B.Sc. (*Fellow*); A. E. Russell, Esq., B.Sc. (*Fellow*); G. C. D. Russell, Esq. (*Associate Fellow*).

Major T. Samarin, U.S.S.R. Asst. Air Attaché; H. Sammons, Esq. (*Associate Fellow*); F. S. Saunders, Esq. (*Associate Fellow*); W. P. Savage, Esq. (*Fellow*); S. Scott-Hall, Esq., M.Sc., A.C.G.I., D.I.C. (*Fellow*); L. H. Scowen, Esq. (*Associate*); G/Capt. A. F. Scroggs, B.A., D.I.C. (*Fellow*); R. B. Scutt, Esq. (*Associate Fellow*); Major T. P. Searight, M.I.A.E., M.S.A.E. (*Fellow*); D. G. Sedge, Esq. (*Student*); The Rt. Hon. Lord Sempill, A.F.C., Past President (*Fellow*); J. E. Serby, Esq., B.A. (*Fellow*); J. Macaulay-Service, Esq. (*Associate Fellow*); P. Shaw, Esq. (*Associate Fellow*); Yuan Shen, Esq., B.Sc. (*Associate Fellow*); Major B. W. Shilson, O.B.E., M.I.Mech.E. (*Fellow*); Sir Oliver Simmonds (*Fellow*); T. Simpson, Esq. (*Associate Fellow*); Mrs. Walker Sinclair (*Companion*); Bruce Skinner, *Exchange Telegraph Co., Ltd.*; Air Marshal Sir Leonard Slatter, K.B.E., C.B., D.S.O., D.F.C., H.Q. Fighter Command; Rear-Admiral M. S. Slattery, R.N. (*Associate Fellow*); Major C. H. Chichester Smith, D.S.C. (*Associate Fellow*); D. C. Smith, Esq., M.A. (*Associate Fellow*); Air Cmdre. J. W. Sowrey, D.S.O., M.C., A.F.C. (*Fellow*); W. F. Spurr, Esq. (*Associate Fellow*); R. S. Stafford, Esq. (*Fellow*); P. G. Stannard, Esq. (*Associate Fellow*); H. C. M. Stevens, Esq. (*Associate Fellow*); Major C. J. Stewart, C.B., O.B.E. (*Fellow*); Major Oliver Stewart, Editor *Aeronautics;* Dr. E. W. Still, B.Sc., A.M.I.Mech.E., A.C.G.I. (*Associate Fellow*); W/Cmdr. R. H. Stocken (*Fellow*); S. J. Stocks, Esq. (*Associate Fellow*); P. H. Stokes, Esq., B.Sc. (*Associate Fellow*); Air Cmdre. Whitney Straight, O.B.E., M.C., D.F.C. (*Companion*); F/Lt. A. H. Stratford, B.Sc. (*Associate Fellow*); Rear-Admiral Sir Murray Sueter, C.B., R.N.; W. A. Summers, Esq. (*Associate*); A. Swan, Esq., B.Sc., A.M.Inst.C.E. (*Fellow*); Mrs. Golda Sztern, D.I.C. (*Associate Fellow*).

Marshal of the R.A.F. Lord Tedder, G.C.B., Chief of the Air Staff; Prof. G. Temple, D.Sc. (*Companion*); Ivor Thomas, Esq., Parliamentary Secretary to the Ministry of Civil Aviation; Dr. A. P. Thurston, M.B.E., M.I.Mech.E., M.I.A.E. (*Fellow*); S. S. Tresilian, Esq., B.A., A.M.I.A.E. (*Associate Fellow*); Marshal of the R.A.F. Viscount Trenchard of Wolfton, G.C.B., D.S.O. (*Hon. Fellow*); Rear-Admiral Trowbridge, Fifth Sea Lord; Col. M. Turner, U.S. Air Attaché.

C. F. Uwins, Esq., O.B.E., A.F.C. (*Fellow*).

Lt.-Col. J. Valensi (*Associate Fellow*); Sir Alliott Verdon-Roe, M.I.Ae.E. (*Fellow*); G. R. Volkert, Esq. (*Fellow*).

C. P. Wadsworth, Esq., B.Sc. (*Associate Fellow*); C. C. Walker, Esq., A.M.Inst.C.E. (*Fellow*); C. J. Walker, Esq. (*Associate Fellow*); J. R. Walker, Esq., *Reuters;* R. R. Walls, Esq., M.A., B.Sc. (*Associate Fellow*); Capt. R. H. Walmsley, R.E., B.Sc. (*Associate Fellow*); F. D. Ward, Esq., B.Sc. (*Graduate*); J. M. Warner, Esq. (*Student*); G/Capt. G. E. Watt, O.B.E., A.F.C., D.I.C. (*Associate Fellow*); H. C. Watts, Esq., M.B.E., M.Inst.C.I. (*Fellow*); Sir Robert Watson Watt, C.B., LL.D., F.R.S., F.Inst.P., M.I.E.E. (*Fellow*); Alderman and Sheriff F. M. Wells; T. C. L. Westbrook, Esq. M.I.P.E. (*Associate Fellow*); Lt. F. P. Whaley, (*Associate*); Alderman Sir George Wilkinson, Bart.; D. L. Hollis Williams, Esq., B.S.c. (*Fellow*); J. A. C. Williams, Esq. (*Associate Fellow*); W. J. Williams, Esq. (*Associate Fellow*); John Wilmot, Min. of Supply and Aircraft Production; Lt. P. S. Wilson, R.N. (*Graduate*); J. C. Wimpenny, Esq. (*Student*); L. A. Wingfield, Esq., M.C., D.F.C. (*Associate*); Lord Winster, Minister of Civil Aviation; Major C. Winter; D. B. Winter, Esq., G.I.Mech.E. (*Associate Fellow*); H. T. Winter, Esq. (*Founder Member*); H. A. Wise, Esq. (*Associate Fellow*);

M. W. Wood, Esq. (*Associate Fellow*); H. E. Worthan, Esq., *Daily Telegraph;* J. Wright, Esq. (*Associate Fellow*); O. Wright, Esq. (*Associate*).

W/Cmdr. H. M. Yeatman (*Associate Fellow*); F. Youldon, Esq.

THE RECEPTION

A Special Council meeting—the 560th meeting of Council—was held at 2.30 p.m. on the 12th January 1946 at which the following resolution was passed:—

"The Council of the Royal Aeronautical Society for the year 1946 wish to place on record their profound admiration of the high spirit and foresight of the Duke of Argyll, Mr. F. H. Wenham, Mr. James Glaisher, Dr. H. W. Diamond, Mr. J. W. Butler, Mr. F. W. Brearey, who, on January 12th 1866 made that historic decision to found the Aeronautical Society of Great Britain. The present Council are proud to have before them at this meeting the original Council Minute book in which Mr. F. W. Brearey recorded the resolution.

"They laid well and truly the foundations of a Society which not only holds the proud distinction of being the oldest Aeronautical Society in the world, but is one whose prestige throughout the world in aviation, eighty years later, is unrivalled.

"Their faith is one which must for ever inspire all those who follow in the Councils of the Society."

Following the Council meeting a reception was held from three o'clock to six o'clock in the offices of the Society at 4, Hamilton Place, which was attended by approximately 650 members and their guests. They were received by the President, Sir Frederick Handley Page, C.B.E., F.R.Ae.S., and Lady Handley Page.

Throughout the afternoon music was provided by the Royal Artillery Orchestra conducted by Captain O. W. Geary, M.B.E., and tea was served in the Library, the Council Room and Committee Room Two.

The whole of the offices of the Society were open during the afternoon to the visitors, and through the courtesy and co-operation of the Aircraft Industry photographs and models of the latest civil and military aircraft were on view in each room.

The following is a list of the exhibits lent for the occasion :—

Blackburn Aircraft Ltd.—Models and photographs of the Blackburn Firebrand I and IV. The model of the Firebrand I has since been presented to the Society, together with the photographs.

The Bristol Aeroplane Co. Ltd.—Models of the Bristol Type 167 Brabazon I and Type 170 Freighter.

The De Havilland Aircraft Co. Ltd.—Models of the D.H. 103 Dove, D.H. 105 Hornet and D.H. 100 Vampire.

English Electric Co. Ltd.—Scale Models of the Handley Page Hampden and Halifax III and the De Havilland Vampire.

The Fairey Aviation Co. Ltd.—Models of the Fairey Firefly and Fairey Flycatcher.

General Aircraft Ltd.—Models of the Hamilcar I and Hamilcar X with models of military cargo such as jeeps, guns.

Another view of some of the guests at the Eightieth Anniversary Dinner at Guildhall, Taken from the orchestra dais.

GLOSTER AIRCRAFT CO. LTD.—Models of the Gloster E.28/39, the original British jet aeroplane, and the Meteor which set up the world's speed record. Photographs of the Meteor have since been presented to the Society.

F. A. HUGHES & CO. LTD.—Model of a Handley Page Halifax. This has now been presented to the Society.

HANDLEY PAGE LTD.—Water-colour painting of a Halifax.

MILES AIRCRAFT LTD.—Photographs of the Miles Aerovan, Gemini, M.28 and Messenger and models of the Miles Aerovan, Marathon and Messenger. The photographs have since been presented to the Society.

D. NAPIER & SON LTD.—Model of the Napier Sabre engine. This model has been presented to the Society.

PERCIVAL AIRCRAFT LTD.—Models and photographs of the Percival Proctor IV, Q.6 and Mew Gull. Photographs of the Proctor IV and of an " artist's impression " of the Percival Merganser have since been presented to the Society.

POWER JETS LTD.—An early axial compressor, the rotor assembly of the Power Jet/Whittle WIA, a model of a Power Jets W2/700 engine, a sectioned combustion chamber of the W2/700 engine and scale models of the Gloster/Whittle E.28/39, the first Allied jet propulsion aeroplane to fly, and the Gloster Meteor.

A. V. ROE & CO. LTD.—A model of the Avro Tudor II and photographs of the Avro Lancaster, Lancastrian, Lincoln, Tudor I, York and Avro XIX. The photographs have since been presented to the Society.

ROLLS-ROYCE LTD.—Demonstration Rolls-Royce Merlin supercharger, with diagrams, and photographs of the Fairey Barracuda, Handley Page Halifax, Avro Lancastrian, De Havilland Mosquito, Supermarine Spitfire and the assembly of a Merlin engine. The photographs have since been presented to the Society.

ROTAX LTD.—Section models of the Merlin magneto; rotary Cowl gill actuator, and electric starter for the Bristol Ceutaurus engine.

SAUNDERS-ROE LTD.—Model of the Saro Lerwick and photographs of the Saro Lerwick and Saro 37 flying-scale model.

VICKERS-ARMSTRONGS LTD.—Model of the Spitfire XXI and photographs of Spitfires, Seafires, Vikings and an interior of the Viking. The photographs have since been presented to the Society.

Members also had an opportunity of seeing the first Minutes of Council for 1866 and the Minutes of the Council meeting held earlier in the afternoon, as well as various historical exhibits belonging to the Society.

In the evening the Graduates and Students Section held a dinner at which the guests were the President of the Society, Sir Frederick Handley Page, C.B.E., and the Secretary, Captain J. Laurence Pritchard.

A number of Branches of the Society have also held celebrations, and others will be celebrating the Eightieth Anniversary of the Society at a later date.

NEW YEAR HONOURS

O.M.

The Right Honourable Winston L. S. Churchill, C.H., F.R.S., M.P., Honorary Fellow.

KNIGHTHOOD.

Ben Lockspeiser, Fellow.

C.B. (Military Division).

Air Commodore F. R. Banks O.B.E., R.A.F., Fellow.
Captain (Acting Rear-Admiral) M. S. Slattery, Assoc. Fellow.

C.B.E. (Military Division).

Act. Air Commodore J. F. Titmus, R.A.F., Assoc. Fellow.
Group Captain R. H. Horniman, R.A.F., Assoc. Fellow.

O.B.E. (Military Division).

G/C. N. C. Ogilvie-Forbes, R.A.F., Assoc.
W/C. A. J. Edmunds, R.A.F., Assoc.
W/C. A. K. Hunter, R.A.F., Assoc. Fellow.
Act. W/C. D. D. M. Butcher, R.A.F.O., Student.
Act. W/C. R. H. C. Brousson, R.A.F.V.R., Assoc.
Act. W/C. S. T. Freeman, R.A.F.V.R., Assoc.
Act. W/C. Keith Hitchins, R.A.F.V.R., Assoc.
Act. W/C. John Jewell, R.A.F., Assoc. Fellow.
Act. W/C. J. D. Sumner, R.A.F.V.R., Assoc. Fellow.
Act. W/C. Joseph Williams, R.A.F., Assoc. Fellow.

M.B.E. (Military Division).

S/L. J. G. Gunn, R.A.F.V.R., Assoc.
Act. S/L. S. F. Mitchell, R.A.F., Assoc. Fellow.
F/L. M. J. I. Kemper, R.A.F.V.R., Student.
F/L. R. J. MacCallum, R.A.F., Assoc.
Act. F/L. Richard Los, R.A.F., Assoc.
Act. F/L. Norman Scott, R.A.F.V.R., Student.
F/O. R. J. McAusland, R.A.F., Companion.
W/O. S. G. Smith, R.A.F., Assoc.

C.B.E. (Civil Division).

Joseph Smith, Fellow.
G. R. Volkert, Fellow.

O.B.E. (Civil Division).

R. H. Chaplin, B.Sc., Fellow.
C. L. Hinings, Assoc. Fellow.
A. C. Lovesey, Assoc. Fellow.
H. J. Penrose, Fellow.
J. B. Prior, Assoc. Fellow.
T. R. Thomas, Fellow.

M.B.E. (Civil Division).

S/L. L. S. Ash, R.A.F.V.R., Assoc. Fellow.
C. R. Burgess, Assoc.
H. E. Chaplin, Fellow.
W. A. Hargreaves, Fellow.
D. F. Horne, Assoc. Fellow.
Harold Rogerson, Fellow.
F. S. Saunders, Assoc. Fellow.
W/C. R. C. Warren, Assoc.
H. M. Wilson, Ph.D., A.M.I.Mech.E., Assoc. Fellow.

FLUTTER
OF
PROPELLER BLADES

by

J. V. INGLESBY, M.A., D.I.C., Assoc. Fellow.

MR. J. V. INGLESBY read Mechanical Sciences at Cambridge, obtaining his degree in 1935. *He joined the Stress Office at Saunders-Roe, Ltd., and later took a year's Post Graduate Course at the Imperial College, London. This was followed by shop experience with Vickers-Armstrongs, Ltd., at Weybridge. In* 1940 *he joined the Propeller Stress Office of the de Havilland Aircraft Co., Ltd., where he worked on propeller flutter and other problems. Since* 1943 *Mr. Inglesby has been doing similar work for the Government. He was elected an Associate Fellow in March,* 1943.

SUMMARY

An analytical study of the flutter of stalled and unstalled propeller blades is recorded. The flutter of unstalled propeller blades investigated is unstable coupled flexural-torsional oscillation, while the flutter of stalled blades is assumed to be unstable torsional oscillation due to aerodynamical hysteresis, which is Studer's theory of stalled flutter.

A method of estimating critical speeds, which is within the scope of Stress Office work, is proposed and examples given.

The observed and calculated flutter speeds of propeller blades are tabulated.

(All statements made and opinions expressed represent the author's own views.)

PART I—COUPLED FLUTTER

§ 1. GENERAL

1.1. *Introductory*

This work is largely a sequel to R. & M. 1518, " Present Position of Investigation of Airscrew Flutter," by W. J. Duncan and A. R. Collar, ref. 1, and familiarity with its text is assumed in the discussion which follows.

1.2. *Scope*

Briefly, the flutter to be investigated is unstable coupled flexural-torsional oscillation. The equations of motion are stated in R. & M. 1518 and these contain dynamical coefficients of three types, inertial, elastic, and aerodynamical. R. & M. 1518, however, deals only with the uniform blade fixed in an air stream of constant velocity. In this investigation, the effect of rotation is introduced as well as variations in tip shape, position of centroid of blade section and effective length of blade (to be explained later).

For each variation of blade, the inertial, elastic and aerodynamical coefficients are derived, and the solution follows precisely as in R. & M. 1518.

In § 2, the effect of different effective lengths of the rotating blade is determined. The blade to be considered is supposed to have a root portion rigid, the remainder, the effective length, having two degrees of freedom in flexure and torsion. The effective length is that value of s for which the flutter speed works out at a minimum. This conception is found to be convenient in the estimation of critical speeds.

In § 2, a uniform blade encastré at the centre of rotation ($s=R$) is taken as the basis and the effect of different values of s/R investigated. The appropriate expressions for the dynamical coefficients are recorded and Tables I and IA contain the results.

In § 3, the effect of position of centroid of the blade section is investigated for a uniform blade encastré at the centre of rotation ($s=R$). Tables II and IIA contain the results.

In § 4, a uniform blade encastré at the centre of rotation ($s=R$) is taken as the basis and the effect of variation in tip shape from $0{\cdot}7s$ to the tip is investigated, the thickness : chord ratio being kept constant. The appropriate expressions for the dynamical coefficients are recorded and Tables III and IIIA and Figure I show the results.

In § 5, a uniform blade encastré at the centre of rotation ($s=R$) is taken as the basis and the effect of linear variation in thickness : chord ratio from $0{\cdot}7s$ to the tip is investigated, the chord being kept constant. The appropriate expressions for the dynamical coefficients are recorded and Tables IV and IVA contain the results.

The application of these results to a propeller blade is described in § 6 and examples are worked out in the Appendix.

1.3. *Symbols*

A_1 Flexural moment of inertia.

a_0 Non-dimensional sectional area coefficient.

a_1 Non-dimensional form of A_1.

B_1 Direct flexual damping coefficient.

B_3 Compound torsional damping coefficient.

b_1, b_3 Non-dimensional forms of B_1, B_3.

C Torsional stiffness per unit length of blade.

c Chord.

f Fundamental natural frequency in torsion.

$F(\eta)$ Torsional distribution function.

$f(\eta)$ Flexural distribution function.

G_3 Torsional moment of inertia.

g_0 Non-dimensional second moment coefficient for section.

g_3 Non-dimensional form of G_3.

h Distance of flexural centre from leading edge, as fraction of chord.

J Moment of inertia per unit length of blade about flexural axis.

J_1 Compound flexural damping coefficient.

J_3 Direct torsional damping coefficient.

j_1, j_3 Non-dimensional forms of J_1, J_3.

K_1 Flexural cross-stiffness.

k_L Lift coefficient.

k_1 Non-dimensional form of K_1.

k_3 Non-dimensional form of torsional aerodynamical stiffness.

$L_\varphi', L_\theta', L_\theta$ Flexural aerodynamical derivatives.

l_φ Flexural elastic stiffness.

$l_z', l_\alpha', l_\alpha$ Non-dimensional derivative coefficients.

$M_\varphi', M_\theta', M_\theta$ Torsional aerodynamical derivatives.

m_θ Torsional elastic stiffness.

$m_\alpha, m_z', m_\alpha'$ Non-dimensional derivative coefficients.

n Index in equation to family of blade sections.

P Product of inertia.

p Non-dimensional form of P.

p_0 Non-dimensional first moment coefficient for section.

s Span.

$T(\xi)$ Function defining section.

X Abscissa for test conic=non-dimensional flexural stiffness coefficient.

y Distance of current point from root of blade.

γ Material density.

ε $\rho/\gamma\vartheta$.

η Distance of current point from root of blade as fraction of span.

ϑ Thickness : chord ratio.

ξ Distance of centroid from leading edge as fraction of chord.

ξ Distance of current point from leading edge as fraction of chord.

ρ Air density.

Fuller definitions of these symbols will be found in R. & M. 1518.

The following symbols are also used :—

G to replace N, which is reserved for rotational speed.

Z to replace R, which is reserved for blade radius.

k constant in expression for natural frequency (not to be confused with k in R. & M. 1518).

x variable to be investigated (not to be confused with x in R. & M. 1518).

Associated with k_a, $x=s/R$.

Associated with k_b, x=centroid to $L\varepsilon$ (chords).

Associated with k_c, x=plan form factor.

Associated with k_d, x=thickness : chord grading

$$x_a, x_b, x_c, x_d$$

are used, but in general the suffixes have been dropped for convenience.

k_a correction for effective length.

k_b correction for position of centroid.

k_c correction for plan form.

k_d correction for thickness : chord grading.

Suffix o refers to root section, such as c_0, t_0, ϑ_0, C_0, J_0.

t thickness (not to be confused with t in R. & M. 1518).

V tip speed.

V_c critical flutter tip speed.

1.4. *Assumptions*

1. Semi-rigidity.
2. For a uniform blade, the flexural and torsional distribution functions $f(\eta)$ and $F(\eta)$ are known, but $f(\eta)$ is too unwieldy for the present investigation.

Hence $f(\eta)=\eta^{1\cdot5}$ is used

$$F(\eta)=\sin\frac{\pi\eta}{2}$$

It will be noted in R. & M. 1518 that for a uniform blade

$$u=\int_0^1 f(\eta)^2\,d\eta=0\cdot25$$

$$w=\int_0^1 f(\eta)\,F(\eta)\,d\eta=0\cdot340$$

If $f(\eta)=\eta^{1\cdot5}$ as assumed,

$$u=0\cdot25$$
$$w=0\cdot3415$$

This shows that $f(\eta)=\eta^{1\cdot5}$ is not much in error.

3. Flexural and torsional distribution functions uninfluenced by variation in tip shape.
4. The flexural axis to be a straight line normal to the root axis.
5. Except when considering the position of centroid, the section assumed is the "normal" form in R. & M. 1518 :

   Distance of maximum ordinate to $L\varepsilon$ (chords), 1/3.

   Distance of centroid to $L\varepsilon$ (chords), 3/7.
6. The section is symmetrical so that chord-wise motion does not occur.
7. The effect of density is neglected throughout (ε=o).
8. Poisson's ratio is taken as 1/3.
9. The values of the non-dimensional aerodynamical coefficients assumed are those recommended in R. & M. 1518 :

$$l_z'=1\cdot5$$
$$l_\alpha'=1\cdot4$$
$$l_\alpha=1\cdot6$$
$$-m_z'=0\cdot375$$
$$-m_\alpha'=0\cdot7$$
$$-m_\alpha=0\cdot4$$

10. The angle of attack is supposed to be small so that the normal force coefficient can be identified with k_L.
11. The effect of compressibility, associated with high tip speeds, is neglected.

1.5. *Conclusions*

The effects described in 1.2. are best seen by reference to Tables IA - IVA and Figure 1.

The effect of centrifugal force may be dismissed in a word. m_θ has a considerable influence on the critical speed whereas the effect of l_φ is negligible. The centrifugal force produces a change in l_φ but none in m_θ. Hence it is reasonable to assume that the effect of centrifugal force may be neglected.

It will be noted that the expression for critical speed in § 6 makes no allowance for blade density. It is shown in R. & M. 1518 that the effect of density is small and may be neglected.

In general estimates agree well with spin tests, though a few of the estimates are somewhat high. See Table V.

M15 and M16 refer to rear tandem propellers. In view of these results, it is suggested that 15 per cent. should be allowed in the estimated flutter speeds of rear units of counter-rotating propellers, to allow for buffetting from the front blades.

The main cause of discrepancy is probably due to variations in the modulus of rigidity.

TABLE I

TABLE II

PROPERTIES OF FOURTEEN BLADES FOR COUPLED FLUTTER

Shape	Basic	Long length	Short length	V. short length	Blunt-nosed	Fine-nosed	Parabolic lenticular
x	1·0	0·8	0·6	0·4	0·4	0·45455	0·5
a_1	0·17320	0·17320	0·17320	0·17320	0·17008	0·17269	0·16667
b_1	0·3	0·315	0·33	0·345	0·3	0·3	0·3
p	0·015600	0·015600	0·015600	0·015600	0·023233	0·009191	0
j_1	0·22140	0·23559	0·24977	0·26396	0·24570	0·20086	0·16811
k_1	0·33194	0·36672	0·40555	0·44844	0·33194	0·33194	0·33194
b_3	−0·043697	−0·046497	−0·049297	−0·052098	−0·019397	−0·064237	−0·096986
g_3	0·020358	0·020358	0·020358	0·020358	0·022241	0·018874	0·016667
j_3	0·089087	0·096627	0·104168	0·111708	0·106275	0·077784	0·065873
k_3	−0·048297	−0·054775	−0·062196	−0·070558	−0·021439	−0·070999	−0·107195
q_0^1	0·0032826	0·0032826	0·0032826	0·0032826	0·0032430	0·0031749	0·0027778
q_1^1	0·018765	0·020199	0·021633	0·023066	0·019490	0·017839	0·015979
α ($\varepsilon=0$)	−0·0051783	−0·0057208	−0·0063266	−0·0069957	−0·0077120	−0·0030509	0
B	−0·014505	−0·017051	−0·019992	−0·023363	−0·006439	−0·021323	−0·032194
Y_c	0·063914	0·069600	0·076021	0·083162	0·073096	0·057385	0·048871
k	2·4674	2·4674	2·4674	2·4674	2·4674	2·4674	2·4674
Z	1·3344	1·2675	1·2023	1·1401	1·4361	1·2429	1·0975
k_a, k_b	1·0	0·9499	0·9010	0·8544	1·0762	0·9314	0·8225

This may vary by $\pm 20\%$ or more of the mean value for different specimens of the same kind of wood. In this connection, it may be noted that similar blades and even blades of the same design, sometimes have widely differing flutter speeds.

Values of modulus of rigidity used in the estimates :

Mahogany	$13{\cdot}5 \times 10^6$ lb./sq. ft.
Walnut	$18{\cdot}5 \times 10^6$ lb./sq. ft.
White seraya	10×10^6 lb./sq. ft.

With one or two possible exceptions, the calculated critical flutter tip speeds are well below the compressibility region so that the effect of compressibility cannot be ascertained.

Only metal blades of abnormally thin

TABLE III

TABLE IV

Shape	Pointed	Fine-tipped	Parabolic	Broad-tipped	Slightly tapered	Tapered	V. tapered
x	1·0	0·75	0·5	0·25	0·75	0·5	0·25
a_1	0·074392	0·082729	0·096063	0·122108	0·15392	0·13463	0·11535
b_1	0·14706	0·16640	0·19371	0·23445	0·3	0·3	0·3
p	0·0072747	0·0078338	0·0087207	0·0106105	0·014157	0·012715	0·011272
j_1	0·09502	0·10583	0·12305	0·15389	0·22140	0·22140	0·22140
k_1	0·16383	0·18526	0·21542	0·26021	0·33194	0·33194	0·33194
b_3	−0·018753	−0·020887	−0·024285	−0·030373	−0·043697	−0·043697	−0·043697
g_3	0·011086	0·011635	0·012565	0·014470	0·018886	0·017414	0·015942
j_3	0·041080	0·044360	0·049821	0·060497	0·089087	0·089087	0·089087
k_3	−0·020745	−0·023136	−0·026923	−0·033668	−0·048297	−0·048297	−0·048297
q_0^1	0·0007718	0·0009012	0·0011310	0·0016543	0·0027065	0·0021828	0·0017119
q_1^1	0·0041315	0·0049405	0·0063586	0·0094691	0·016862	0·014958	0·013056
α ($\varepsilon=0$)	−0·0011918	−0·0014513	−0·0018786	−0·0027610	−0·0046993	−0·0042206	−0·0037416
B	−0·0030723	−0·0038695	−0·0052315	−0·0079033	−0·014505	−0·014505	−0·014505
Y_c	0·037633	0·041186	0·045597	0·051039	0·066443	0·069754	0·074243
k	3·8986	3·7658	3·5617	3·2098	2·6188	2·7901	2·9853
Z	1·7160	1·6460	1·5668	1·4768	1·3094	1·2795	1·2429
k_c, k_d	1·2860	1·2335	1·1742	1·1067	0·9813	0·9589	0·9314

sections are liable to suffer from this type of flutter on account of high values of the modulus of rigidity.

§ 2. Effective Blade Length

Consider a rotating blade of uniform chord and thickness along the effective length. Inboard of the effective length the blade is assumed rigid. Let the ratio of effective length to propeller radius be x.

2.1. *Inertial coefficients*

$$A_1 = s^2 \Sigma \delta m f(\eta_i)^2$$

$$P = s \Sigma \delta m c (\bar{\xi} - h) f(\eta) F(\eta)$$

$$G_3 = \Sigma \delta m c^2 (\bar{\xi} - h)^2 F(\eta_i)^2$$

where δm is the mass of a slice of thickness $dy = s d\eta$. The mass of this slice is $2sc^2{}_0 \gamma \vartheta a_0 d\eta_i$

$$\therefore A_1 = 2s^3 c^2{}_0 \gamma \vartheta_0 a_0 \int_0^1 f(\eta_i)^2 d\eta_i$$

Interpolated Results for Coupled Flutter

TABLE Ia

x_a s/R	k_a
0·95	0·9874
0·9	0·9749
0·85	0·9624
0·8	0·9499
0·75	0·9375
0·7	0·9252
0·65	0·9130
0·6	0·9010
0·55	0·8891
0·5	0·8773
0·45	0·8657

TABLE IIa

x_b Centroid to $L\varepsilon$	k_b
0·4	1·0762
0·41	1·0497
0·42	1·0230
0·43	0·9962
0·44	0·9695
0·45	0·9432
0·46	0·9174
0·47	0·8922
0·48	0·8679
0·49	0·8446
0·5	0·8225

TABLE IIIa

x_c Plan-form factor	k_c
1·0	1·2860
0·9	1·2670
0·8	1·2450
0·7	1·2218
0·6	1·1982
0·5	1·1742
0·4	1·1493
0·3	1·1219
0·2	1·0900
0·1	1·0506
0	1·0

TABLE IVa

x_d t/c grading	k_d
1·0	1·0
0·95	0·9965
0·9	0·9929
0·85	0·9892
0·8	0·9853
0·75	0·9813
0·7	0·9772
0·6	0·9684
0·5	0·9589
0·4	0·9486
0·3	0·9374

Interpolated Results for Stalled Flutter

TABLE Ib

x_a s/R	k_a
0·95	0·9845
0·9	0·9692
0·85	0·9540
0·8	0·9390
0·75	0·9242
0·7	0·9096
0·65	0·8953
0·6	0·8812
0·55	0·8673
0·5	0·8537
0·45	0·8404

TABLE IIb

x_b Centroid to $L\varepsilon$	k_b
0·4	1·0018
0·41	1·0031
0·42	1·0021
0·43	0·9996
0·44	0·9956
0·45	0·9905
0·46	0·9843
0·47	0·9773
0·48	0·9697
0·49	0·9616
0·5	0·9533

TABLE IIIb

x_c Plan-form factor	k_c
1·0	1·3366
0·9	1·3153
0·8	1·2923
0·7	1·2669
0·6	1·2388
0·5	1·2075
0·4	1·1729
0·3	1·1348
0·2	1·0932
0·1	1·0482
0	1·0

TABLE IVb

x_d t/c grading	k_d
1·0	1·0
0·95	0·9971
0·9	0·9941
0·85	0·9911
0·8	0·9880
0·75	0·9849
0·7	0·9817
0·6	0·9752
0·5	0·9685
0·4	0·9615
0·3	0·9542

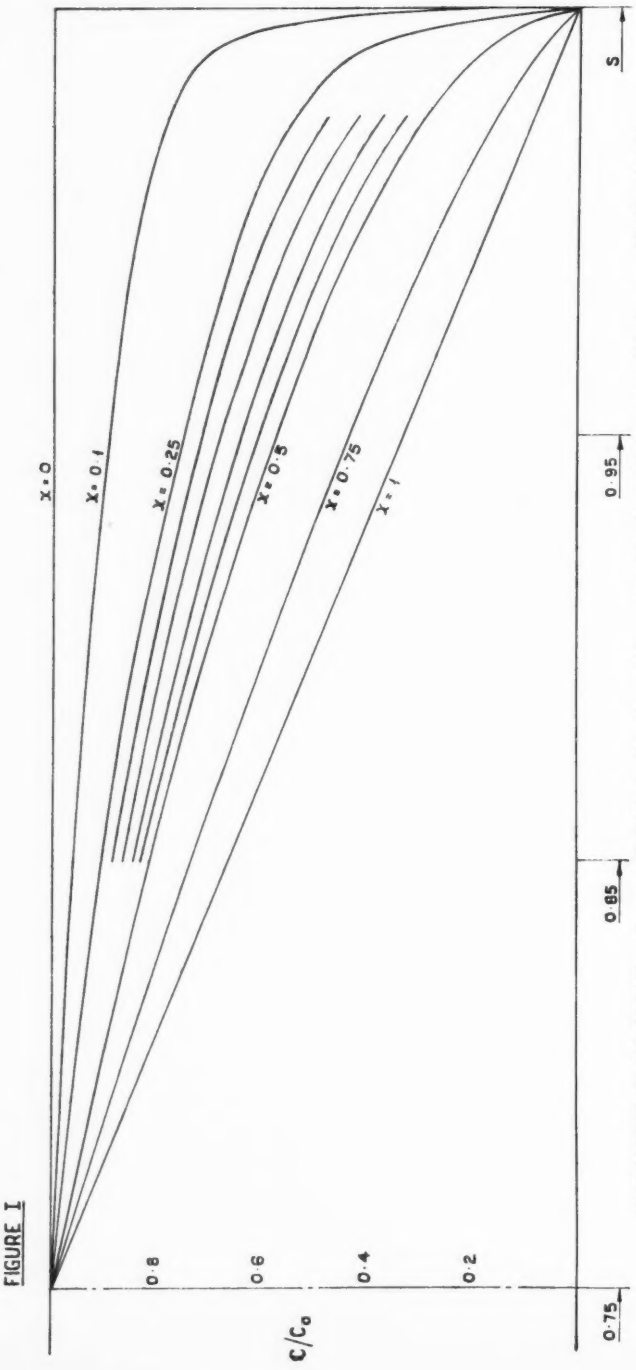


FIGURE 1

UNTWISTED PLAN FORMS. Curves of $C\,C_0$ in the tip region. x=plan form factor. c=chord. s=effective length.

$$=2s^3c^2{}_0\gamma\vartheta_0 a_0\int_0^1 r_i^3 dr_i$$

$$P=2s^2c^3{}_0\gamma\vartheta_0(p_0-ha_0)\int_0^1 f(r_i)F(r_i)dr_i$$

$$=2s^2c^3{}_0\gamma\vartheta_0(p_0-ha_0)\int_0^1 r_i^{1\cdot5}\sin\frac{\pi r_i}{2}\,dr_i$$

$$G_3=2sc^4{}_0\gamma\vartheta_0(g_0-hp_0+h^2a_0)\int_0^1 F(r_i)^2dr_i$$

$$=2sc^4{}_0\gamma\vartheta_0(g_0-hp_0+h^2a_0)\int_0^1\sin^2\frac{\pi r_i}{2}\,dr_i$$

2.2. *Elastic coefficients*

The elastic coefficients are l_φ and m_θ. As the critical speed is unaffected by putting $X=o$, l_φ may be taken as zero.

m_θ is obtained from the expression

$$m_\theta=4\pi^2f^2i_3$$

where f=natural frequency in torsion, and this is obtained from the expression

$$4\pi^2f^2=k\frac{C_0}{s^2J_0}$$

where k is easily found if the torsional distribution function is known.

2.3. *Aerodynamical coefficients*

Let V be the tip speed.

Hence the air speed along the blade is $(1-x+r_ix)V$. This neglects inflow which may be appreciable at the inboard sections, but the effect is thought to be small.

$$\therefore -L_\varphi{}' =\rho s^3c_0l_z{}'\int_0^1(1-x+r_ix)Vf(r_i)^2dr_i$$

$$=\rho Vs^3c_0l_z{}'\int_0^1(1-x+r_ix)r_i^3dr_i$$

$$-L_\theta{}' =\rho s^2c^2{}_0(l_x{}'-hl_z{}')\int_0^1(1-x+r_ix)Vf(r_i)F(r_i)dr_i$$

$$=\rho Vs^2c^2{}_0(l_x{}'-hl_z{}')\int_0^1(1-x+r_ix)r_i^{1\cdot5}\sin\frac{\pi r_i}{2}\,dr_i$$

$$-L_\theta =\rho s^2c_0l_\alpha\int_0^1[(1-x+r_ix)V]^2f(r_i)F(r_i)dr_i$$

$$=\rho V^2s^2c_0l_\alpha\int_0^1(1-x+r_ix)^2r_i^{1\cdot5}\sin\frac{\pi r_i}{2}\,dr_i$$

$$-M_\theta{}' =\rho s^2c^2{}_0(-m_z{}'-hl_z{}')\int_0^1(1-x+r_ix)Vf(r_i)F(r_i)dr_i$$

$$=\rho Vs^2c^2{}_0(-m_z{}'-hl_z{}')\int_0^1(1-x+r_ix)r_i^{1\cdot5}\sin\frac{\pi r_i}{2}\,dr_i$$

$$-M_\theta{}' =\rho sc^3{}_0[-m_\alpha{}'-h(l_\alpha{}'-m_z{}')+h^2l_z{}']\int_0^1(1-x+r_ix)VF(r_i)^2dr_i$$

$$=\rho Vsc^3{}_0[-m_\alpha{}'-h(l_\alpha{}'-m_z{}')+h^2l_z{}']\int_0^1(1-x+r_ix)\sin^2\frac{\pi r_i}{2}\,dr_i$$

$$-M_\theta = \rho s c^2_0(-m_\alpha - hl_\alpha)\int_0^1 [(1-x+\tau_1 x)V]^2 F(\tau_1)^2 d\tau_1$$

$$= \rho V^2 s c^2_0(-m_\alpha - hl_\alpha)\int_0^1 (1-x+\tau_1 x)\sin^2\frac{\pi\tau_1}{2} d\tau_1$$

Referring to Table 2 and equations (73) to (84) in R. & M. 1518, the symbols used in Table I of this report are seen to have the following meanings :

$$a_1 = 2a_0\int_0^1 \tau_1^3 d\tau_1$$

$$b_1 = l_z\cdot\int_0^1 (1-x+\tau_1 x)\tau_1^3 d\tau_1$$

$$p = 2(p_0 - ha_0)\int_0^1 \tau_1^{1\cdot5}\sin\frac{\pi\tau_1}{2} d\tau_1$$

$$j_1 = (l_\alpha\cdot - hl_z\cdot)\int_0^1 (1-x+\tau_1 x)\tau_1^{1\cdot5}\sin\frac{\pi\tau_1}{2} d\tau_1$$

$$k_1 = l_\alpha\int_0^1 (1-x+\tau_1 x)^2\cdot\tau_1^{1\cdot5}\sin\frac{\pi\tau_1}{2} d\tau_1$$

$$b_3 = (-m_z\cdot - hl_\alpha\cdot)\int_0^1 (1-x+\tau_1 x)\tau_1^{1\cdot5}\sin\frac{\pi\tau_1}{2} d\tau_1$$

$$g_3 = 2(g_0 - 2hp_0 + h^2 a_0)\int_0^1 \sin^2\frac{\pi\tau_1}{2} d\tau_1$$

$$j_3 = [-m_\alpha\cdot - h(l_\alpha\cdot - m_z\cdot) + h^2 l_z\cdot]\int_0^1 (1-x+\tau_1 x)\sin^2\frac{\pi\tau_1}{2} d\tau_1$$

$$k_3 = (-m_\alpha - hl_\alpha)\int_0^1 (1-x+\tau_1 x)^2\sin^2\frac{\pi\tau_1}{2} d\tau_1$$

$$q'_0 = a_1 g_3 - p^2$$

$$q'_1 = a_1 j_3 + b_1 g_3 - p(j_1 + b_3)$$

$$\alpha = -pk_1 \quad (\varepsilon = 0)$$

$$\beta = b_3 k_1$$

$$Y_c = -\frac{q'_1\alpha + q'_0\beta}{q'_1 a_1 + q'_0 b_1}$$

$$k = \frac{4\pi^2 f^2 s^2 I_0}{C_0}$$

$$Z = \left\{\frac{km\int_0^1 \sin^2\frac{\pi\tau_1}{2} d\tau_1}{Y_c - k_3}\right\}^{\frac{1}{2}}$$ The integral is that associated with g_3.

§ 3. Position of Centroid of Section

In considering the effect of position of centroid, the section assumed is defined by the expression :

$$\Gamma(\xi)=\frac{(n+1)^{n+1}}{2n^n}\xi^n(1-\xi)$$

A full explanation of this expression appears in R. & M. 1518.

The blades whose properties are shown in Table II have uniform chord and thickness and are encastré at the centre of rotation ($s=R$). The dynamical coefficients have the same form as for the " normal " section.

§ 4. Untwisted Plan Form

Consider a rotating blade encastré at the centre of rotation ($s=R$). Let the blade shape be as follows :

From $r_1=0$ to $r_1=0{\cdot}7$, $c=c_0$
$t=t_0$

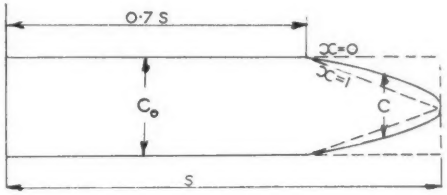
From $r_1=0{\cdot}7$ to $r_1=1$, $c=0{\cdot}3^{-x}(1-r_1)^x c_0$
$t=0{\cdot}3^{-x}(1-r_1)^x t_0$

where x may vary from 0 to 1.

The thickness : chord ratio is kept constant.

With $x=0{\cdot}5$, the tip shape is parabolic. The paddle blade is given by $x=0$. See Figure II.

FIGURE II



4.1. *Inertial coefficients*

$$A_1=2s^3\gamma\vartheta_0 a_0\int_0^1 c^2 f(r_1)^2 dr_1$$

$$=2s^3c^2{}_0\gamma\vartheta_0 a_0[0{\cdot}3^{-2x}\int_{0{\cdot}7}^1 r_1^3(1-r_1)^{2x}dr_1+\int_0^{0{\cdot}7} r_1^3 dr_1]$$

$$P=2s^2\gamma\vartheta_0(p_0-ha_0)\int_0^1 c^3 f(r_1)F(r_1)dr_1$$

$$=2s^2c^3{}_0\gamma\vartheta_0(p_0-ha_0)$$
$$\times[0{\cdot}3^{-3x}\int_{0{\cdot}7}^1 r_1^{1.5}\sin\frac{\pi r_1}{2}\cdot(1-r_1)^{3x}dr_1+\int_0^{0{\cdot}7} r_1^{1.5}\sin\frac{\pi r_1}{2}\,dr_1]$$

$$G_3=2s\gamma\vartheta_0(g_0-2hp_0+h^2a_0)\int_0^1 c^4F(r_1)^2dr_1$$

$$=2sc^4{}_0\gamma\vartheta_0(g_0-2hp_0+h^2a_0)$$
$$\times[0{\cdot}3^{-4x}\int_{0{\cdot}7}^1\sin^2\frac{\pi r_1}{2}\cdot(1-r_1)^{1x}dr_1+\int_0^{0{\cdot}7}\sin^2\frac{\pi r_1}{2}\,dr_1]$$

4.2. *Elastic coefficients*

Take $l_\phi=0$

$$m_0=4\pi^2f^2a_2$$

where $4\pi^2f^2=k\dfrac{C_0}{s^2J_0}$

In determining the value of k, $F(r_1)=\sin\dfrac{\pi r_1}{2}$ has been assumed. See Table III.

4.3. *Aerodynamical coefficients*

Let V be the tip speed.

Hence the air speed along the blade is $r_1 V$.

$$\therefore -L_\phi' = \rho s^3 l_z' \int_0^1 r_1 V c f(r_1)^2 dr_1$$

$$= \rho V s^3 c_0 l_z' \left[0{\cdot}3^{-x} \int_{0{\cdot}7}^1 r_1^4 (1-r_1)^x dr_1 + \int_0^{0{\cdot}7} r_1^4 dr_1\right]$$

$$-L_\theta' = \rho s^2 (l_x' - h l_z') \int_0^1 r_1 V c^2 f(r_1) F(r_1) dr_1$$

$$= \rho V s^2 c^2{}_0 (l_x' - h l_z')$$

$$\times \left[0{\cdot}3^{-2x} \int_{0{\cdot}7}^1 r_1^{2{\cdot}5} \sin \frac{\pi r_1}{2} (1-r_1)^{2x} dr_1 + \int_0^{0{\cdot}7} r_1^{2{\cdot}5} \sin \frac{\pi r_1}{2} dr_1\right]$$

$$-L_\theta = \rho s^2 l_x \int_0^1 (r_1 V)^2 c f(r_1) F(r_1) dr_1$$

$$= \rho V^2 s^2 c_0 l_\alpha \left[0{\cdot}3^{-x} \int_{0{\cdot}7}^1 r_1^{3{\cdot}5} \sin \frac{\pi r_1}{2} (1-r_1)^x dr_1 + \int_0^{0{\cdot}7} r_1^{3{\cdot}5} \sin \frac{\pi r_1}{2} dr_1\right]$$

$$-M\phi' = \rho s^2 (-m_z' - h l_z') \int_0^1 \eta V c^2 f(r_1) F(r_1) dr_1$$

$$= \rho V s^2 c^2{}_0 (-m_z' - h l_z')$$

$$\times \left[0{\cdot}3^{-2x} \int_{0{\cdot}7}^1 r_1^{2{\cdot}5} \sin \frac{\pi r_1}{2} (1-r_1)^{2x} dr_1 + \int_0^{0{\cdot}7} r_1^{2{\cdot}5} \sin \frac{\pi r_1}{2} dr_1\right]$$

$$-M_0' = \rho s \left[-m_x' - h(l_x' - m_z') + h^2 l_z'\right] \int_0^1 r_1 V c^3 F(r_1)^2 dr_1$$

$$= \rho V s c^3{}_0 \left[-m_x' - h(l_x' - m_z') + h^2 l_z'\right]$$

$$\times \left[0{\cdot}3^{-3x} \int_{0{\cdot}7}^1 r_1 \sin^2 \frac{\pi r_1}{2} (1-r_1)^{3x} dr_1 + \int_1^{0{\cdot}7} r_1 \sin^2 \frac{\pi r_1}{2} dr_1\right]$$

$$-M_\theta = \rho s (-m_x - h l_x) \int_{0{\cdot}7}^1 (r_1 V)^2 c^2 F(r_1)^2 dr_1$$

$$= \rho V^2 s c^2{}_0 (-m_x - h l_x)$$

$$\times 0{\cdot}3^{-2x} \int_{0{\cdot}7}^1 r_1^2 \sin^2 \frac{\pi r_1}{2} (1-r_1)^{2x} dr_1 + \int_0^{0{\cdot}7} r_1^2 \sin^2 \frac{\pi r_1}{2} dr_1\Big]$$

The meanings of the symbols in Table III are similar to those in Tables I and II and are found in the same way.

§ 5. Thickness: Chord Grading

Consider a rotating blade, encastré at the centre of rotation ($s=R$). Let the blade shape be as follows:

From $r_1=0$ to $r_1=1$, $c=c_0$
From $r_1=0$ to $r_1=0{\cdot}7$, $\vartheta=\vartheta_0$

From $r_1=0{\cdot}7$ to $r_1=1$, $\vartheta=\dfrac{\vartheta_0}{0{\cdot}3}[1-0{\cdot}7x-r_1(1-x)]$

where x may vary from 0 to 1.
x is the ratio of $t\,c$ at $r_1=1$ to $t\,c$ at $r_1=0{\cdot}7$.

5.1. *Inertial coefficients*

$$A_1=2s^3c^3{}_0\gamma a_0\int_0^1\vartheta f(r_1)^2dr_1$$

$$=2s^3c^2{}_0\gamma\vartheta_0a_0\times\left\{\frac{1}{0{\cdot}3}\int_{0{\cdot}7}^1r_1^3[1-0{\cdot}7x-r_1(1-x)]dr_1+\int_0^{0{\cdot}7}r_1^3dr_1\right\}$$

$$P=-2s^2c^3{}_0\gamma(p_0-ha_0)\int_0^1\vartheta f(r_1)F(r_1)dr_1$$

$$=2s^2c^3{}_0\gamma\vartheta_0(p_0-ha_0)\times\left\{\frac{1}{0{\cdot}3}\int_{0{\cdot}7}^1r_1^{1{\cdot}5}\sin\frac{\pi r_1}{2}[1-0{\cdot}7x-r_1(1-x)]dr_1+\int_0^{0{\cdot}7}r_1^{1{\cdot}5}\sin\frac{\pi r_1}{2}dr_1\right\}$$

$$G_3=2sc^4{}_0\gamma(g_0-2hp_0+h^2a_0)\int_0^1\vartheta F(r_1)^2dr_1$$

$$=2sc^4{}_0\gamma\vartheta_0(g_0-2hp_0+h^2a_0)\times\left\{\frac{1}{0{\cdot}3}\int_{0{\cdot}7}^1\sin^2\frac{\pi r_1}{2}[1-0{\cdot}7x-r_1(1-x)]dr_1+\int_0^{0{\cdot}7}\sin^2\frac{\pi r_1}{2}dr_1\right\}$$

5.2. *Elastic coefficients*

Take $l_\phi=0$

$$m_0=4\pi^2f^2G_3$$

where $4\pi^2f^2=k\dfrac{C_0}{sJ_0}$

In determining the value of k, $F(r_1)=\sin\pi r_1/2$ has been assumed. See Table IV.

5.3. *Aerodynamical coefficients*

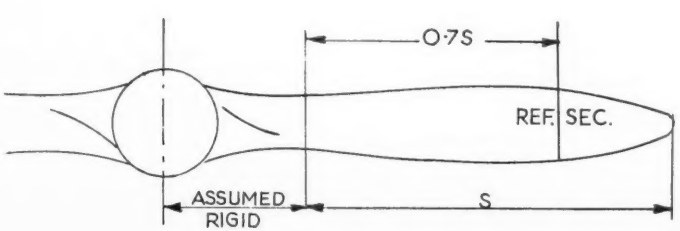
These are unchanged for moderate variations of ϑ.

The meanings of the symbols in Table IV are similar to those in Tables I–III and are found in the same way.

§ 6. METHOD OF APPLICATION

The method of estimating the flutter

FIGURE III



speeds of propeller blades is as follows:

The blade is divided into two parts:

1. Inboard portion—assumed rigid.

2. Outboard portion—assumed flexible.

This is the effective length of blade in flutter. See Figure III.

The critical flutter speed is given by the expression:

$$V_c = 1{\cdot}3344\, k_a k_b k_c k_d\, (c/s)\, \{\, (t/c)^3\, G/\rho \,\}^{\frac{1}{2}}$$

where

V_c=critical flutter tip speed (ft/sec).

s=effective length (inches).

This is the length for which

$$(c/s)\, \{\, (t/c)^3\, G/\rho \,\}^{\frac{1}{2}}$$

is minimum.

c=chord at reference section (inches). The reference section is taken at $0{\cdot}3s$ from the tip (hereafter referred to as $0{\cdot}7s$).

t/c=thickness: chord ratio at ref. sec.

G=modulus of rigidity (lb./sq. ft.), if varying along blade, at ref. sec.

ρ=air density (slug/cu. ft.).

0·002378 slug/cu. ft. at 15°C. and 760 mm.

k_a=correction for effective length. Table Ia.

k_b=correction for position of centroid. Table IIa.

k_c=correction for plan form. Figure I and Table IIIa.

k_d=correction for thickness: chord grading. Table IVa.

In the Tables:

Associated with k_a, $x_a = s/R$ where R=propeller radius.

Associated with k_b, x_b=centroid to $L\varepsilon$ (chords).

Associated with k_c, x_c=plan form factor. See Figure I.

Associated with k_d, x_d=thickness: chord grading, defined as ratio t/c tip to t/c at reference section.

To apply the flutter speed formula, proceed as follows:

6.1. *Effective length in flutter*

Try various lengths of s and calculate $(c/s)\, \{\, (t/c)^3\, G/\rho \,\}^{\frac{1}{2}}$ for each. The effective length (by definition) is that for which $(c/s)\, \{\, (t/c)^3 G/\rho \,\}^{\frac{1}{2}}$ is minimum.

The effective length usually varies between the full blade length and $0{\cdot}75R$.

6.2. *Correction for effective length*

Find the ratio of effective length to propeller radius and hence k_a from Table Ia.

6.3. *Correction for position of centroid*

Find the distance of the centroid from the leading edge (chords). If this varies along the blade, take centroid to $L\varepsilon$ at the reference section as typical. Then obtain k_b from Table IIa.

6.4. *Correction for plan form*

Plot out the untwisted plan (chord/chord at ref. sec.) from $0{\cdot}7s$ to the tip on Figure I and obtain the best value of x_c. Then obtain k_c from Table IIIa.

6.5. *Correction for thickness: chord grading*

Plot out the thickness: chord ratio from $0{\cdot}7s$ to the tip and draw the best equivalent straight line, passing through t/c at $0{\cdot}7s$. Find the ratio of t/c at tip to t/c at $0{\cdot}7s$ and hence k_d from Table IVa.

6.6. *Critical flutter speed*

The appropriate value of V_c is then calculated from the expression given, and if required the rotational speed is easily found.

Tables Ia–IVa are the interpolated results of Tables I–IV.

Examples in the Appendix will help to clarify the method.

Table V contains a comparison between calculated and observed flutter speeds.

PART II—STALLED FLUTTER

§ 7. GENERAL

7.1. *Introductory*

This investigation is based on the experimental observations of H. L. Studer on a

stalled aerofoil, recorded in his "Experimentelle Untersuchungen über Flugelschingungen," ref. 2.

W. S. Farren has shown, ref. 3, that an aerofoil rotating about a spanwise axis has greater lift in the stalling region with the angle of attack increasing than with the angle of attack decreasing. Thus it is reasonable to suppose that a hysteresis loop will be formed by a vibrating aerofoil. Studer puts forward the view that stalled flutter is due to this hysteresis. Briefly, his reasons are as follows:

1. Since, as experiment shows, only a small aerodynamical pressure is needed to cause a rapid increase of amplitude, a process must be at work which liberates a considerable amount of energy. If the aerodynamical law is double valued, this is possible.
2. Stalled flutter can exist as pure torsional vibration. Thus coupling in two degrees of freedom is not required.

It should further be noted that resonance with the disturbance due to eddies shed in the lee of the stalled aerofoil must be ruled out. The eddy frequency is given by the expression:

$$fc/V = 1 - 0{\cdot}028\alpha \text{ approx.}$$

where f=frequency of alternate eddies, ref. 4, and this bears no resemblance to the natural frequency in torsion when applied to Studer's observed flutter speeds.

The estimation of critical flutter speeds of stalled propeller blades is based on the assumption that this aerodynamical hysteresis takes place.

7.2. *Scope*

The flutter to be investigated is unstable torsional oscillation due to air load hysteresis. The same blade shapes are dealt with as for coupled flutter.

In § 8 the general theory is discussed.

In § 9 the appropriate expression for the flutter speed is given for various effective lengths of a uniform blade. Table Ib contains the results.

In § 10 the appropriate expression for the flutter speed is given for various positions of the centroid of the blade section for a uniform blade encastré at the centre of rotation ($s=R$). Table IIb contains the results.

In § 11 the appropriate expression for the flutter speed is given for various tip shapes from $0{\cdot}7s$ to the tip, the thickness : chord ratio being constant. The blade is encastré at the centre of rotation ($s=R$) and from root to $0{\cdot}7s$ the blade is uniform. Table IIIb and Figure I show the results.

In § 12 the appropriate expression for the flutter speed is given for various linear variations of thickness : chord ratio from $0{\cdot}7s$ to the tip, the chord being constant. The blade is encastré at the centre of rotation ($s=R$) and from root to $0{\cdot}7s$ the blade is uniform. Table IVb contains the results.

The application of these results is described in § 12 and an example worked out in the Appendix.

7.3. *Symbols*

Apart from symbols already in use, the following are introduced:

m	mass of aerofoil.
μ	mass ratio (defined in § 8).
I	moment of inertia about flexural axis.
rc	radius of gyration about flexural axis.
D	damping coefficient in torsional vibration.
Δ	logarithmic decrement in torsional vibration.
q	natural frequency in torsion (cycles/sec.).
p	max. offset of centre of pressure from flexural axis.
k_z	normal air load coefficient for stationary aerofoil.
$+\delta k_z$	increase in k_z due to increasing α.
$-\delta k_z$	decrease in k_z due to decreasing α.
k_x	tangential air load coefficient for stationary aerofoil.
δk_x	change in k_x due to changing α.
$\delta\alpha$	displacement in torsional oscillation.
$\pm\delta\bar{\alpha}$	amplitude of torsional oscillation.

V_c critical speed of aerofoil, as well as critical tip speed of propeller blade.

Q constant.

7.4. *Assumptions*

1. The torsional distribution function for a uniform blade is

$$F(r_1) = \sin \frac{\pi r_1}{2}$$

and this is assumed to be unchanged by variations in tip shape.

2. The flexural axis to be a straight line normal to root axis.

3. The same blade section is used as for coupled flutter.

4. The effect of compressibility, associated with high tip speeds, is neglected.

7.5. *Conclusions*

The effect of variations in blade shape, size and material are best seen by reference to the expression in §12 and Tables Ib–IVb.

The centrifugal force has no effect as the mode is torsional.

It will be realised that phenomena associated with stalling are often vague and inexact, but it can be seen from Tables V and VI that the method of estimation proposed serves as a useful guide for determining the proximity of the danger zone.

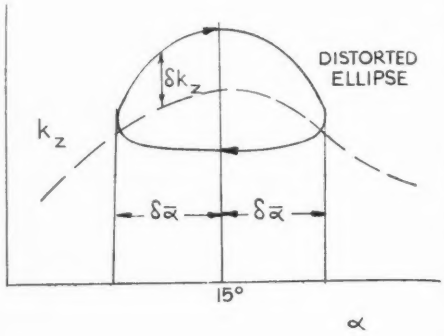
Densities used in the estimates are :

Mahogany	1·0 slug/cu. ft.
Walnut	1·1 slugs/cu. ft.
White seraya	0·9 slug/cu. ft.

§ 8. Basic Theory

Suppose an initial disturbance, imparted to a stalled aerofoil, causes it to undergo torsional oscillation. It is reasonable to assume that δk_z describes an ellipse with $\delta\alpha$. See Figure IV. As $\delta\alpha$ performs simple harmonic motion, it can be readily shown that δk_z is proportional to $\dot{\alpha}$. Thus the hysteresis effect may be described as "negative air damping." If the moment due to this negative damping is equal and opposite to the moment due to internal damping at any instant, the same will be true at every instant throughout the cycle.

FIGURE IV



The centre of pressure probably varies somewhat with time in the stalling region. Let p be the maximum offset of the centre of pressure from the flexural axis.

For an aerofoil of uniform section oscillating with uniform amplitude along the span, as in Studer's experiments :

$$\text{Moment (max.)} = p.\rho V^2 sc.\delta k_z \text{ max.}$$

This neglects δk_x which is usually very small compared with δk_z.

δk_z max. is approximately proportional to $\delta\bar{\alpha}$ and $\sqrt{q}$. This is seen from Studer's experiments.

$$\therefore \text{Moment (max.)} = p.\rho V^2 sc.\sqrt{q}.\delta\bar{\alpha} \times \text{constant.} \quad \text{(i)}$$

The area enclosed by δk_z and $\delta\alpha$ is

$$\pi.\delta\alpha.\delta k_z \text{ max.}$$

If required,

Energy input per cycle

$$= p.\rho V^2 sc.\pi\delta\bar{\alpha}\delta k_z \text{ max.}$$

Moment due to internal damping is given by

$$\frac{\Delta Iq}{\pi}\dot{\alpha}$$

$$\therefore \text{Moment (max.)} = -\frac{\Delta Iq^2}{\pi}\delta\bar{\alpha}. \quad \text{(ii)}$$

If required,

Energy absorbed per cycle

$$= \frac{2}{\pi}\Delta Iq^2\delta\bar{\alpha}^2$$

TABLE V

ESTIMATED AND OBSERVED FLUTTER SPEEDS OF WOODEN PROPELLER BLADES

Spin tests from *AS*23—reference 6

Propeller	Blade angle at $r/R=0.95$	Observed r.p.m. (lowest recorded)	Coupled flutter: Estimated r.p.m.	Coupled flutter: % error	Stalled flutter: Estimated r.p.m.	Stalled flutter: % error
*M*1*	13·0°	1450	1430	− 1·4	—	—
*M*2	16·2°	870	890	+ 2·3	815	− 6·3
*M*3	15·9°	1150	1065	− 7·4	1000	−13·0
*M*4	19·6°	800	800	0	760	− 5·0
*M*5	11·6°	1150	1045	− 9·1	—	—
*M*6	12·4°	1150	1405	+22·2	—	—
*M*7	11·7°	1500	1650	+10·0	—	—
*M*8	11·0°	1220	895	−26·6	—	—
*M*9*	10·9°	1280	1215	− 5·1	—	—
*M*10	23·8°	1325	—	—	1505	+13·6
*M*11	17·8°	1100	1245	+13·2	1080	− 1·8
*M*12	12·6°	1000	1185	+18·5	—	—
*M*13	15·9°	950	975	+ 2·6	860	− 9·5
*M*14	15·9°	950	1185	+24·7	1030	+ 8·4
*M*15†	15·0°	1050	1245	+18·6	1110	+ 5·7
*M*16†	14·0°	1150	1455	+26·5	—	—
*M*17*	10·9°	1000	905	− 9·5	—	—
*M*18*	11·6°	1450	1600	+10·3	—	—
*M*19	16·8°	850	1160	+36·4	1010	+18·8
*M*20	19·0°	1000	1120	+12·0	1010	+ 1·0
*M*21	13·6°	1100	845	−23·2	—	—
*M*22*	16·2°	1450	1465	+ 1·0	1215	−16·2
*M*23*	12·7°	No flutter	2785	—	—	—
*M*24*	14·0°	No flutter	2200	—	—	—
*W*1*	13·7°	1300	1405	+ 8·1	—	—
*W*2	11·9°	1595	1265	−20·7	—	—
*W*3	13·0°	1460	1330	− 8·9	—	—
*W*4*	13·3°	1400	1515	+ 8·2	—	—
*W*5	14·0°	1500	1345	−10·3	—	—
*W*6	13·6°	1380	1245	− 9·8	—	—
*W*7	22·9°	1200	—	—	1295	+ 7·9
*WS*1	14·6°	1200	1550	+29·2	—	—
*WS*2*	17·6°	1300	1125	−13·5	925	−28·8
*WS*3*	11·9°	1450	1525	+ 5·2	—	—
*WS*4	11·9°	No flutter up to 1680	1730	—	—	—

M = Mahogany.
W = Walnut.
WS = White seraya.
For blade angles at tip $< 20°$, coupled flutter is possible.
For blade angles at tip $> 15°$, stalled flutter is possible.

* marks the blades known to be fabric covered. The quality and effectiveness of fabric covering differ considerably. In certain conditions, fabric may be almost ineffective in stiffening the blade.

† rear tandem propellers.

TABLE VI

ESTIMATED AND OBSERVED FLUTTER SPEEDS OF DURALUMIN PROPELLER BLADES

Spin tests from *AS23*—reference 6 Stalled flutter

Propeller	Blade angle at $r/R=0.95$	Observed r.p.m. (lowest recorded)	Estimated r.p.m.	% error
*D*1	14·7°	1250	1270	+ 1·6
*D*2	22·7°	960 (smooth up to this speed)	1740	—
*D*3	16·4°	1200 (smooth up to this speed)	1670	—
*D*4	17·4°	975?	1355	+39·0?
*D*5a	18·0°	1440	1565	+ 8·7
*D*5b	18·0°	1650 (smooth up to this speed)	1640	—
*D*6	19·3°	2060 (smooth up to this speed)	2090	—
*D*7	19·3°	1590	1455	− 8·5
*D*8	19·3°	1500	1115	−25·7
*D*9a	21·3°	900 (Rough running)	1300	—
*D*9b	21·3°	960 (Rough running)	1385	—

From equations (i) and (ii), the critical condition is given by the expression :

$$p.\rho V^2{}_c\, sc.\sqrt{q}.\delta\alpha.Q-\frac{1}{\pi}\,\Delta Iq^2\delta\alpha=0$$

where Q is a constant.

$$\therefore \frac{\rho V^2{}_c\, sc^2}{\Delta Iq^{1\cdot5}}=\frac{1}{\pi Q}.\frac{c}{p} \quad . \quad \text{(iii)}$$

Studer's experiments on an aerofoil with Clark Y section—12 cm. chord and 40 cm. span—show that the lowest observed flutter speed may be expressed as follows :

$$\frac{\frac{1}{2}\rho V^2{}_c\, sc}{\mu r^2q^{1\cdot5}D}=2 \text{ (roundly)}$$

in kg. metre units

$$\text{where } \mu=\frac{4m}{\pi\rho sc^2}\ ,$$

$$D=\Delta/2\pi$$

Variations in flexural stiffness make no apparent difference to this result.

$$\therefore \frac{\rho V^2{}_c\, sc^2}{\Delta Iq^{1\cdot5}}=\frac{8}{\pi^2\rho sc^3}$$

$$=10^4 \text{ (roundly)} \quad . \quad . \quad . \quad \text{(iv)}$$

where $s=0{\cdot}4$ metre

$c=0{\cdot}12$ metre

$\rho=0{\cdot}115$ kg. sec.^{2}/metre^4

Applying this result to the propeller blade, so that $\delta\alpha$, V and V_c hereafter refer to the tip :

(*a*) Negative air damping.

Consider an elemental strip of width $sd\eta$.

Moment at any instant $= p\rho(\eta V)^2sd\eta c\delta k_z$

δk_z is approximately proportional to $F(\eta)\delta\alpha$ and $\sqrt{q}$.

$\therefore$ Moment $=p\rho(\eta V)^2sd\eta c\sqrt{q}F(\eta)\delta\alpha Q.$

From equations (iii) and (iv),

$$\frac{1}{\pi Q}.\frac{c}{p}=10^4$$

$$\therefore \text{Moment}=\frac{1}{10^4\pi}\rho(\eta V)^2sd\eta c^2\sqrt{q}F(\eta)\delta\alpha$$

$\therefore$ Equiv. moment at tip

$$=\frac{1}{10^4\pi}\rho(\eta V)^2sd\eta c^2\sqrt{q}F(\eta)^2\delta\alpha$$

$\therefore$ Total moment at tip

$$=\frac{1}{10^4\pi}\rho V^2s\sqrt{q}\delta\alpha\int_0^1 c^2\eta^2F(\eta)^2d\eta \quad . \quad \text{(v)}$$

(*b*) *Internal damping*

Consider an elemental strip of width $sd\eta$

$$\text{Moment at any instant}=-\frac{1}{\pi}\Delta q^2dIF(\eta)\delta\alpha$$

where $dI=Jsd\eta$

$$\therefore \text{Moment}=-\frac{1}{\pi}\Delta sd\eta Jq^2F(\eta)\delta\alpha$$

$\therefore$ Equiv. moment at tip

$$=-\frac{1}{\pi}\Delta sd\eta Jq^2F(\eta)^2\delta\alpha$$

$\therefore$ Total moment at tip

$$=-\frac{1}{\pi}\Delta sq^2\delta\alpha\int_0^1 JF(\eta_i)^2 d\eta_i \quad . \text{ (vi)}$$

From equations (v) and (vi), the critical condition is given by the expression :

$$\frac{1}{10^4\pi}\rho V^2{}_c\, s\sqrt{q}\,\delta\alpha\int_0^1 c^2\eta_i^2 F(\eta_i)^2 d\eta_i$$

$$-\frac{1}{\pi}\Delta sq^2\delta\alpha\int_0^1 JF(\eta_i)^2 d\eta_i=0$$

$$\therefore V^2{}_c=10^4\frac{\Delta}{\rho}q^{1\cdot5}\frac{\int_0^1 JF(\eta_i)^2 d\eta_i}{\int_0^1 c^2\eta_i^2 F(\eta_i)^2 d\eta_i} \quad . \text{ (vii)}$$

where $F(\eta_i)=\sin\frac{\pi\eta_i}{2}$

For the blades in question, appropriate critical speeds are readily deduced from this expression.

§ 9. Effective Length

$c=c_0$ throughout.
$\vartheta=\vartheta_0$ throughout.

$$V^2{}_c=10^4(km)^{0.75}[2(g_0-2hp_0+h^2a_0)]^{0.25}$$
$$\times\frac{\int_0^1 \sin^2\frac{\pi\eta_i}{2}d\eta_i}{\int_0^1(1-x+\eta_i x)^2\sin^2\frac{\pi\eta_i}{2}\,d\eta_i}\,c^2{}_0\frac{\Delta}{\rho}\sqrt{\frac{\vartheta^5{}_0}{s^3}}\sqrt[4]{\gamma G^3}$$

§ 10. Position of Centroid

$c=c_0$ throughout.
$\vartheta=\vartheta_0$ throughout.
$s=R$

$$V^2{}_c=10^4(km)^{0.75}[2(g_0-2hp_0+h^2a_0)]^{0.25}$$
$$\times\frac{\int_0^1 \sin^2\frac{\pi\eta_i}{2}d\eta_i}{\int_0^1 \eta_i^2\sin^2\frac{\pi\eta_i}{2}d\eta_i}\,c^2{}_0\frac{\Delta}{\rho}\sqrt{\frac{\vartheta^5{}_0}{s^3}}\sqrt[4]{\gamma G^3}$$

§ 11. Plan Form

$c=0{\cdot}3^{-x}(1-\eta_i)^x c_0$ from $\eta_i=1$ to $\eta_i=0{\cdot}7$
$c=c_0$ from $\eta_i=0{\cdot}7$ to $\eta_i=0$
$\vartheta=\vartheta_0$ throughout
$s=R$

$$V^2{}_c=10^4(km)^{0.75}[2(g_0-2hp_0+h^2a_0)]^{0.25}$$
$$\times\frac{\frac{1}{(0{\cdot}3)^{4x}}\int_{0,7}^1(1-\eta_i)^{4x}\sin^2\frac{\pi\eta_i}{2}d\eta_i+\int_0^{0,7}\sin^2\frac{\pi\eta_i}{2}d\eta_i}{\frac{1}{(0{\cdot}3)^{2x}}\int_{0,7}^1\eta_i^2(1-\eta_i)^{2x}\sin^2\frac{\pi\eta_i}{2}d\eta_i+\int_0^{0,7}\sin^2\frac{\pi\eta_i}{2}d\eta_i}$$

$$\times c^2{}_0 \frac{\Delta}{\rho} \sqrt{\frac{\vartheta_0{}^5}{s^3}} \sqrt[4]{\gamma G^3}$$

§ 12. Thickness: Chord Grading

$\vartheta = \vartheta_0[1 - 0{\cdot}7x - \tau_i(1-x)]$ from $\tau_i = 1$ to $\tau_i = 0{\cdot}7$

$\vartheta = \vartheta_0$ from $\tau_i = 0{\cdot}7$ to $\tau_i = 0$

$c = c_0$ throughout

$s = R$

$$V^2{}_c = 10^4 (km)^{0.75} [2(g_0 - 2hp_0 + h^2 a_0)]^{0.25}$$

$$\times \frac{\frac{1}{0{\cdot}3}\int_{0{\cdot}7}^{1} [1 - 0{\cdot}7x - \tau_i(1-x)] \sin^2 \frac{\pi \tau_i}{2} d\tau_i + \int_0^{0.7} \sin^2 \frac{\pi \tau_i}{2} d\tau_i}{\int_0^1 \tau_i{}^2 \sin^2 \frac{\pi \tau_i}{2} d\tau_i}$$

$$\times c^2{}_0 \frac{\Delta}{\rho} \sqrt{\frac{\vartheta_0{}^5}{s^3}} \sqrt[4]{\gamma G^3}$$

§ 13. Method of Application

The method of estimating flutter speeds of stalled propeller blades is precisely as for coupled flutter.

The blade is divided into two parts:

1. Inboard portion—assumed rigid.
2. Outboard portion—assumed flexible.

Logically, the critical flutter speed should be given by the expression:

$$V_c = 65 k_a k_b k_c k_d c \sqrt{\frac{\Delta}{\rho}} \sqrt[4]{\frac{(t/c)^5}{s^3}} \sqrt[8]{\gamma G^3}$$

where V_c = critical flutter tip speed (ft./sec.).

s = effective length (ft.).

This is the length for which

$$c \sqrt{\frac{\Delta}{\rho}} \sqrt[4]{\frac{(t/c)^5}{s^3}} \sqrt[8]{\gamma G^3}$$

is minimum.

c = chord at reference section (ft.).

The reference section is taken at $0{\cdot}7s$.

t/c = thickness: chord ratio at ref. sec.

G = modulus of rigidity (lb./sq. ft.), if varying along blade, at ref. sec.

γ = blade density (slugs/cu. ft.), if varying along blade, at ref. sec.

Δ = logarithmic decrement in torsional oscillation.

ρ = air density (slugs/cu. ft.).

0·002378 slug/cu. ft. at 15° and 760 mm.

k_a = correction for effective length. Table Ib.

k_b = correction for position of centroid. Table IIb.

k_c = correction for plan form. Figure I and Table IIIb.

k_d = correction for thickness: chord grading. Table IVb.

It will be noted that s and c must be in feet to keep the units consistent.

However, to obtain critical flutter speeds of propeller blades to accord with observed flutter speeds, the following formula must be used:

$$V_c = 17{\cdot}7 k_a k_b k_c k_d c \sqrt{\frac{\Delta}{\rho}} \sqrt[4]{\frac{(t/c)^5}{s^3}} \sqrt[8]{\gamma G^3}$$

where values of Δ to be used are as follows:

Wood blades $\Delta = 0{\cdot}04$

Metal blades $\Delta = 0{\cdot}01$

This compares with the following experimental values of Δ, ref. 5:

Mahogany or Walnut $\Delta = 0{\cdot}06$ } Logarithmic decrement of materials in torsion (damping small).

Aluminium $\Delta = 0{\cdot}006$ }

It may be found that the logarithmic decrements of propeller blades in torsional oscillation differ somewhat from the values proposed, but fairly consistent flutter speeds should be obtained if these values are adhered to.

The difference between the formula calculated from test results and that proposed may be explained in a variety of ways. The discrepancy may be due to critical flutter tip speeds of blades being of the order of thirty times the flutter speeds of Studer's models. Also torsional frequencies of blades and models differ widely and this may affect the dynamical stalling characteristics.

An example is worked in the Appendix.

APPENDIX

Coupled Flutter Speed Estimation

$$V_c = 1{\cdot}3344 k_a k_b k_c k_d \frac{c}{s} \sqrt{\frac{(t/c)^3 G}{\rho}}$$

Propeller : *M*1 — Altitude : Sea-level
Material : Mahogany — $\rho = 0{\cdot}002378$ slug/cu. ft.
$G = 13{\cdot}5 \times 10^6$ lb./sq. ft. — Ref. sec. : 0·7*s*

s/*R*	*s*	Ref. sec.	*c*	*t*/*c*	$(c/s)\{(t/c)^3 G/\rho\}^{\frac{1}{2}}$
0·9101	51·87*	0·7270	8·93	0·115	505·9
0·8333	47·50	0·75	8·66	0·113	521·8
0·75	42·75	0·775	8·32	0·1105	538·6

* Full blade length. Values of *s*/*R* are chosen to give convenient reference sections.

Effective length : *s*/*R* = 0·9101 — *t*/*c* grading : $x_d = 0{\cdot}94$, $k_d = 0{\cdot}9958$
Centroid to *LE* : $x_b = 0{\cdot}4505$, $k_b = 0{\cdot}9419$ — $V_c = 711{\cdot}3$ ft./sec.
Plan-form factor : $x_c = 0{\cdot}4$, $k_c = 1{\cdot}1493$ — Propeller dia. : $D = 9{\cdot}5$ ft.
Estimated flutter speed : $= 60 V_c/\pi D = 1430$ r.p.m.

Coupled Flutter Speed Estimation

$$V_c = 1{\cdot}3344 k_a k_b k_c k_d \frac{c}{s} \sqrt{\frac{(t/c)^3 G}{\rho}}$$

Propeller : *M*8 — Altitude : Sea-level
Material : Mahogany — $\rho = 0{\cdot}002378$ slug/cu. ft.
$G = 13{\cdot}5 \times 10^6$ lb./sq. ft. — Ref. sec. : 0·7*s*

s/*R*	*s*	Ref. sec.	*c*	*t*/*c*	$(c/s)\{(t/c)^3 G/\rho\}^{\frac{1}{2}}$
0·9116	56·72*	0·7265	9·85	0·094	376·9
0·8333	51·85	0·75	9·46	0·089	365·0
0·75	46·66	0·775	9·01	0·084	354·2
0·6667	41·48	0·8	8·55	0·0795	348·1
0·5833	36·29	0·825	8·04	0·076	349·7

* Full blade length.

Effective length : *s*/*R* = 0·6667 — *t*/*c* grading : $x_d = 1{\cdot}04$, $k_d = 1{\cdot}0028$
Centroid to *LE* : $x_b = 0{\cdot}44$, $k_b = 0{\cdot}9695$ — $V_c = 485{\cdot}3$ ft./sec.
Plan-form factor : $x_c = 0{\cdot}49$, $k_c = 1{\cdot}1718$ — Propeller dia. : $D = 10{\cdot}37$ ft.
Estimated flutter speed : $= 60 V_c/\pi D = 895$ r.p.m.

Stalling Flutter Speed Estimation

$$V_c = 17{\cdot}7 k_a k_b k_c k_d \, c \sqrt{\frac{\Delta}{\rho}} \sqrt[4]{\frac{(t/c)^5}{s^3}} \sqrt[8]{\gamma G^3}$$

Propeller : *D*1
Material : Duralumin
$G = 5{\cdot}5 \times 10^8$ lb./sq. ft.
$\gamma = 5{\cdot}4$ slugs/cu. ft.
$\Delta = 0{\cdot}01$

Altitude : Sea-level
$\rho = 0{\cdot}002378$ slug/cu. ft.
Ref. sec. : 0·7s

s/R	s	Ref. sec.	c	t/c	$c\sqrt{\frac{\Delta}{\rho}}\sqrt[4]{\frac{(t/c)^5}{s^3}}\sqrt[8]{\gamma G^3}$
0·9	5·175*	0·73	0·559	0·088	37·47
0·8333	4·792	0·75	0·541	0·087	37·87
0·75	4·312	0·775	0·515	0·0865	38·74

* Full blade length.

Effective length : $s/R = 0{\cdot}9$, $k_a = 0{\cdot}9692$
Centroid to *LE* : $x_b = 0{\cdot}44$, $k_b = 0{\cdot}9956$
Plan-form factor : $x_c = 0{\cdot}47$, $k_c = 1{\cdot}1971$
t/*c* grading : $x_d = 0{\cdot}935$, $k_d = 0{\cdot}9962$
$V_c = 763{\cdot}3$ ft./sec.
Propeller dia. : $D = 11{\cdot}5$ ft.
Estimated flutter speed : $= 60 V_c/\pi D$
$= 1270$ r.p.m.

CONCLUDING REMARKS

1. The flutter investigated in this report is purely of aerodynamical origin. It depends on the inherent properties of the blade and in no way is it related to the characteristics of the associated engine. If a propeller is free from coupled and stalled flutter, it is still possible that vibration, excited by a non-uniform torque, a non-uniform air flow, out-of-balance or eccentricity, may be experienced.

2. The method of estimating flutter speeds of both stalled and unstalled propeller blades applies to solid blades only, under spin test conditions. In general, it may be said that a propeller free from flutter under spin test conditions will be free from flutter in flight at the same rotational speed and blade setting.

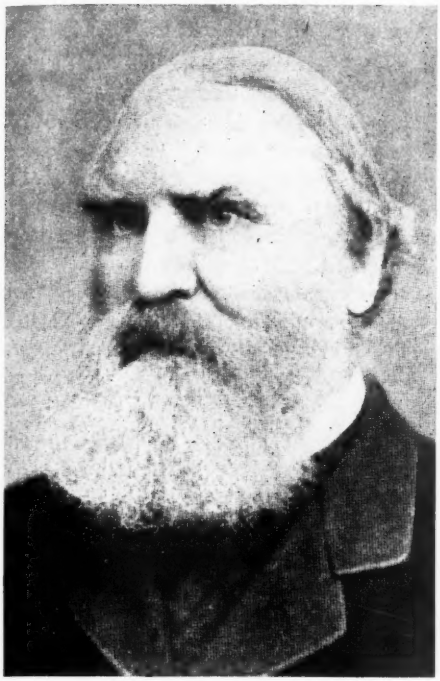
3. The method of estimation is based on the assumption that the critical flutter speed depends mainly on the outboard third or so of the blade. Also it is assumed that each correction factor in the critical flutter speed formulae is independent of the other correction factors.

4. Although the examples have been worked out on old-fashioned fixed-pitch propellers, the principles are equally applicable to modern variable-pitch propellers with blades of improved materials.

5. By idealising the blade to some extent, it has been possible to condense some complex mathematics to a form which can be handled by the average Stressman.

REFERENCES

1. Duncan, W. J., and Collar, A. R. The Present Position of the Investigation of Airscrew Flutter. R. & M. **1518**, December, 1932.
2. Studer, H. L. Experimentelle Untersuchungen über Flugelschwingungen, Mitteilungen aus dem Institut fur Aerodynamik, No. 4, Zurich, December, **1936**. Translation ARC 2777.
3. Farren, W. S. Reactions of a Wing, whose Angle of Incidence is Changing Rapidly. R. & M. **1648**, January, **1935**.
4. Fage, A., and Johansen, F. C. The Structure of Vortex Streets. R. & M. **1143**, August, **1927**.
5. Walker, P. B. Note on Material and Structural Damping. Report No. AD3079. Royal Aircraft Establishment, Farnborough, November, **1936**.
6. Johnson, F. W. Further Notes on the Flutter of Airscrew Blades. Report No. AS23. Royal Aircraft Establishment, Farnborough, March, **1933**.



FIFTY YEARS AGO

FIFTY YEARS AGO, on the 31*st January* 1896, *F. W. Brearey, the first secretary and driving force behind the formation of the Society and throughout its first thirty years, died at the age of eighty.*

The following article, written by the late Major B. F. S. Baden-Powell, at that time Secretary of the Society, appeared in the first number of the Journal of the Aeronautical Society, in January 1897.

THE LATE MR. F. W. BREAREY

WHILE the world is waiting for the new developments which seem to broaden out in contemplation of the command of the atmosphere by man, so that he may be free to traverse it in every direction, we would remind those who would give honour where honour is due, not only to offer praise to the successful inventor, but also to those whose pioneering exertions have led to eventual success—for such it must be regarded. Prominent among these in our own country is the name of Frederick William Brearey, who seems very early in life to have been a dreamer of aerial dreams.

It may account for these youthful aspirations that his father was a friend of the late Sir George Cayley, of Stillingfleet, near Scarborough, the latter being the place of his birth in 1816. His father and sister were occasionally the witnesses of the experiments in flight made by the scientific baronet, and although Mr. Fred. Brearey does not remember any influence upon his mind resulting from overheard conversation, yet the idea seems possible. Although he says he remembers seeing Sir George at York, he never heard of his aerial experiments until after he arrived at manhood, and only then from his sister. Sir George Cayley's papers and experiments, published in the " Mechanic's Magazine " of that period, have since become to him and other students of aeronautics a storehouse of knowledge.

The time came when Mr. Brearey's aerial dreams began to take shape, but not until the year 1865 did he make any progress.

In the January of the next year the Aeronautical Society of Great Britain was launched from the House of the Duke of Argyll at Campden Hill. A nobleman of such acknowledged scientific attainments becoming President of the Society somewhat abated the ridicule of Mr. Brearey's friends, but it has accompanied him more or less as each attempt was reported a failure.

As soon as it became known that the Society was formed in Great Britain, there came plans and suggestions from all parts of the civilized world, with applications for the money which it was supposed that John Bull was anxious to lavish upon inventors, and from that time until now, nearly thirty years, the copies of letters, all in the handwriting of Mr. Brearey, and the letters received, testify to the gratuitous labours of the Honorary Secretary. The Société Française de Navigation Aérienne soon voted him their gold medal, and, as showing the effect which his papers, read at the meetings held at the Society of Arts, and magazine and newspaper articles, for the most part reprinted in other countries, had upon scientific minds, one of several letters spontaneously addressed to him will suffice. It was from the then President of the American Society of Civil Engineers, Mr. O. Chanute, dated from New York, February 3rd, 1882 :—" We are in this country aware of your long-continued experiments and efforts to promote a solution of the problem of aerial navigation, and know that it is through your influence that the subject has been cleared of much rubbish, and placed upon a scientific and firm basis."

It was soon accepted by Mr. Brearey as conviction, that aerial navigation could never be accomplished by balloons, however useful they might be in their own sphere, so that all his attention and experiments were directed to the mechanical means of attaining it. These were so suggestive and encouraging that in a lecture room he was able to show various forms of sustained flight over the heads of the audience, and although he has lectured in more than fifty cities and towns in England and Scotland, and liberated models of two or three pounds' weight, with a spread of wing of 12½ft., he never caused an accident which created anything but amusement. Not so a lecturer at the Royal Polytechnic who, lecturing there upon the flight of one of Mr. Brearey's models, apologised for the absence of it upon one occasion " because the model had flown at a lady and the lady flew at him." The action of these models, of which he used to show more than thirty in his lectures, was very precarious, but occasionally their flight would surprise him. At Plymouth, for instance, one wing-flapped bird flew twice round the room, and returned to his hand on the platform, as if directed. At Truro, in a very large hall, a screw-propelled plane flew to the end of the hall, and, without touching the wall, turned round and got fixed on the gas fittings on the platform. At the Hartley Institute, Southampton, he liberated from his hand the model of an albatross, with wings of 12½ft. in width, made of very slender material, both as to the shaft of the wing and the covering ; so slender, indeed, that in holding it out ready for flight, the wings dropped on each side of him, so that no one would have thought flight possible, but the moment that action was imparted to those drooping wings, they stiffened out, and through the reflex action at the tip of the wing which effects propulsion, the model flew the whole length of the room, about 2ft. above the heads of the audience, and, although rising at the end, just managed to clear the gallery. This was repeated with like result, in obedience to continued applause. With screw propelled planes he was equally successful, and it is on record how he suggested to Captain (now Lieut.-Colonel) Templer the means of sending information to a distance from a balloon. Mr. Brearey having supplied the apparatus of simple construction, Capt. Templer liberated it from a height, when it travelled back to

Woolwich Arsenal against the wind, which carried away the balloon. Thus was conveyed a dead weight, the prerunner of the live weight conveyed in like manner by Herr Lilienthal's machine near Berlin—at that time a member of the Society. This successful experiment was recorded in the "Daily Telegraph," October 10th, 1879, and "Daily News," October 21st.

As Mr. Brearey has written a work, "The Atmosphere as a Medium of Travel," which awaits a publisher, I must abstain from much that I should like to chronicle, but I cannot forbear giving a few anecdotes. One of his correspondents, advocating the propulsion of balloons, thinks that it may be accomplished thus: He would surround the balloon with compartments in which hawks can be located, confined by attachments to little leather breeches. When it is desired to propel the balloon, the aeronaut yells, and the hawks, liberated in this frightened manner, will lighten the balloon so that it will rise.

He even believes that they may be trained to pull altogether, and so hawk the balloon about the country. Another correspondent who, being an engineer, was supposed to understand the supporting power of surfaces when launched into the air from a height, seriously proposed the erection of towers at distances suitable to the effective gliding transmission of the surface. The passengers were to place themselves under this surface, and glide downwards to the next tower.

A lift would take them to the top while the apparatus would be hauled up for their reception, and away they would float off to the next tower, and so on, and so on.

These are a sample of some of the wild schemes of enthusiasts. Mr. Brearey has upon several occasions lost blood in the cause, and copiously, too, at the Alexandra Palace, when a screw-blade, revolving at a great velocity, produced by the great muscular effort he was exerting in turning a handle, flew off, and hitting him in the face, cut a portion of his nose off, at the same time cutting open his cheek. The nose was cleverly sewn on, but the after effect resulted in an operation by which the eye was barely saved. Again, when returning from the Crystal Palace, where for many days he had been in attendance, witnessing some interesting experiments in plane propulsion, a railway accident produced concussion of the brain, and confined him to his bed for many weeks. It was in connection with these experiments that the following ridiculous incident is related. Mr. Brearey had made an appointment to meet the Duke of Argyll, the late Duke of Sutherland, and the Earl of Dufferin. After they had spent some time in examining the steam-driven apparatus, said he, "We proceeded to the lower level exit to catch the train. On passing the cloak room the Earl started from us, saying he would be back directly, as he had left his coat there."

On attempting to pass the barrier, the ticket collector exclaimed to the Earl, who had the coat over his arm, "Holloa, where did you get that coat?" The Earl was unaware that a ticket was attached to the coat, which had caught the inspector's attention, and caused him to look with suspicion upon the whole party. "Yes," said the Earl innocently, "there was no one in the cloak room so I took it."

This was too much for the inspector, who, casting a glance at us, said in an authoritative tone, "Has anyone else boned a coat?"

"Come with me," said the Duke of Argyll to the Earl. "What does he mean by boned?"

" Stole it," says the Earl.

As we reached the cloak room the attendant, who had left it for a short time, was just entering the room, thus confirming the Earl's statement. Of course, this was quite satisfactory. " But, " says Mr. Brearey, " I shall not easily forget my indignation at the man's manner, nor my admiration at the suppression of any anger which must have been felt by the party. After they had departed I could not avoid saying to the inspector, " Do you know who that gentleman was that you accused of stealing a coat?"

" I neither know nor care," said the man carelessly.

" Well," I said, " he was the Earl of Dufferin, Governor-General of Canada ; the taller of the two others was the Duke of Sutherland, and the other was the Duke of Argyll."

" Good God !" said the man, " you don't say so ?"

With respect to the ultimate issue of the late plane propelled experiments, Mr. Brearey, who—at least, theoretically—became possessed of as much knowledge as anyone in this kingdom, said that there were two systems by which success has been ascertained to be certain, so far as ascent is securable by mechanical means alone, viz., Maxim's and Phillip's. The former answers to the prognostication of the Duke of Argyll, expressed when presiding over the first meeting of the Society in 1866.

" I think it quite certain that, if the air is ever to be navigated, it will not be by individual men flying ; but that it is quite possible vessels may be invented which will carry a number of men, and the motive force of which will not be muscular action."

Mr. Maxim says that it is only for such dire purposes as war that his inventive genius has aimed at. This means heavy weights. Phillip's will come within the capacity of the pleasure seeker. Both have yet to come under control when set free in the air. Both inventors are members of the Society.

" Then," said Mr. Brearey, " will come the real test, and the real danger, but, that success will be ultimately attained, who that considers man's pluck, luck, and perseverance can doubt ?"

On January 31st, 1896, Frederick William Brearey suddenly and peacefully passed away.

THE SOCIETY'S AWARDS

The Society offers a number of valuable awards, most of them annually. Full particulars of the conditions attaching to these awards may be obtained on application to the Secretary.

Society's Gold Medal

This is the highest honour which the Society can confer for work of an outstanding or fundamental nature in aeronautics.

British Gold Medal for Aeronautics

The British Gold Medal for Aeronautics is awarded for an achievement leading to advancement in aeronautical science.

Simms Gold Medal

The Simms Gold Medal is awarded annually for the best paper read in any year before the Society on any science allied to aeronautics, e.g., meteorology, wireless telegraphy, instruments.

The George Taylor (of Australia) Gold Medal

The Taylor Gold Medal is awarded annually, at the discretion of the Council, for the most valuable paper submitted or read during the previous session.

Wakefield Gold Medal

The Wakefield Gold Medal is awarded annually to the designer of any invention or apparatus tending towards safety in flying, and is open to members or non-members.

Society's Silver Medal

The Society's Silver Medal is awarded, at the discretion of the Council, for some advance in aeronautical design.

British Silver Medal for Aeronautics

The British Silver Medal for Aeronautics is awarded for an achievement leading to advancement in aeronautical science.

Society's Bronze Medal

The Society's Bronze Medal is awarded, at the discretion of the Council, under the same conditions as those for the Silver Medal, but for some less important advance in aeronautical design.

Wilbur Wright Memorial Premium

The Wilbur Wright Memorial Lecture is held annually, a premium of fifty pounds being awarded to the lecturer invited by the Council to deliver the lecture. The lecture is usually given alternately by an American and an Englishman, and is the most important aeronautical lecture of the year. It is delivered whenever possible, on the last Thursday in May of each year.

British Empire and Commonwealth Lecture

The Council of the Royal Aeronautical Society have completed the arrangements for the founding of a British Empire and Commonwealth Lecture.

The lecture, on any aeronautical subject approved by the Council, will be delivered annually in September in London, by a lecturer, chosen in alternate years from the British Dominions and Colonies and Great Britain.

The Council, by founding this British Empire and Commonwealth Lecture, are anxious to encourage new ideas and new points of view from all parts of the British Empire and Commonwealth, and to make the Lecture second only in importance to the Wilbur Wright Memorial Lecture.

The British Empire and Commonwealth Lecture will have a premium of £50 attached to it, and in the case of lecturers coming from the Dominions and Colonies an allowance up to £100 will be paid towards the Lecturer's expenses.

R.38 Memorial Prize

The R.38 Memorial Prize is offered annually for the best paper received by the Society on some subject of a technical nature in the science of aeronautics, preference being given to papers which relate to airships. The prize is twenty-five guineas.

The Herbert Akroyd Stuart Lectures

Under the will of the late Mr. Herbert Akroyd Stuart a sum of £700 is held in trust by the Society for the offer of a prize every two years, for the best paper or lecture read or given before the Society dealing with the Origin and Development of Heavy-oil Aero Engines. The prize is open to members and non-members.

Edward Busk Memorial Prize

The Edward Busk Memorial Prize is offered annually for the best paper received by the Society on some subject of a technical nature in connection with aeroplanes (including seaplanes). Its value is twenty guineas.

Pilcher Memorial Prize

The Pilcher Memorial Prize is offered annually, at the discretion of the Council, for the best paper by a Student on heavier-than-air craft or any analogous subject. Its value is five guineas.

Usborne Prize

The Usborne Prize is offered annually, at the discretion of the Council, for the best paper by a Student on some subject in connection with Aero Engines. Its value is five guineas.

Major Baden-Powell Memorial Prize

The Major Baden-Powell Memorial Prize is awarded in May and December of each year to the student who is considered the best student by the examiners in the Society's Association Fellowship examinations. Its value is three guineas.

Elliott Memorial Prize

The Elliott Memorial Prize is awarded twice yearly to the apprentice at Halton who has the highest percentage of marks in the passing-out examination. Its value is 2½ guineas for each award.

R. P. Alston Memorial Prize

The R. P. Alston Memorial Prize is awarded to any Graduate or Student of the Society for work done leading to improvement in the safety of aircraft, and particularly for improvement in stability and control. Its value is approximately £5.

Branch Prize

The Council offer an annual prize of twenty guineas for the best paper read before the Branches during the previous lecture Session. The prize is open to any member of the Society or of any Branch.

Journal Premium Awards

The Council has set aside an annual sum of £250 to be given as premium awards to authors of papers published in the Journal.

AN APPRECIATION

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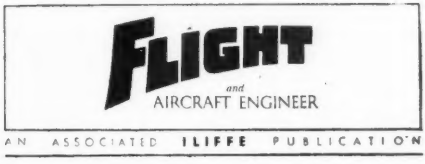

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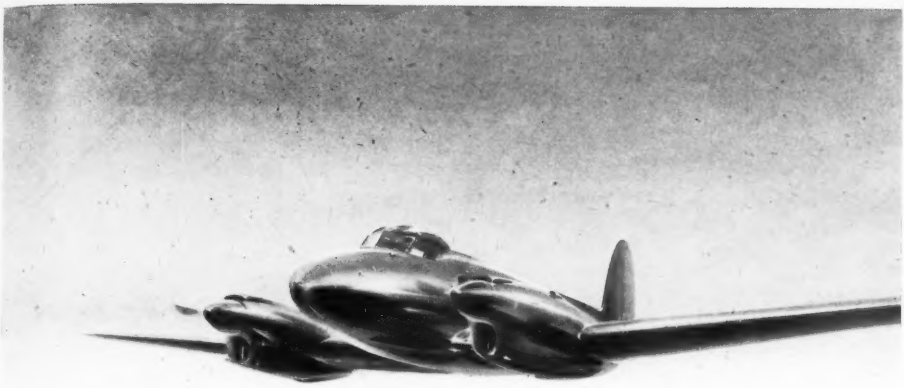

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